DOCUMENT RESUME

ED 168 838 SE 026 916

AUTHOR	Webb, Norman L.; Charles, Randall I.
TITLE	Mathematical Problem Solving Project Technical Report III: Module Development and Formative Evaluation. Final Report.
INSTITUTION	Indiana Univ., Bloomington. Mathematics Education Development Center.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	May 77
GRANT	NSF-PES-74-15045
NOTE	158p.; For related documents, see SE 026 911-934
EDRS PRICE	MF01/PC07 Plus Postage.
DESCRIPTORS	*Educational Research; Elementary Education; *Elementary School Mathematics; *Evaluation; Instruction; *Mathematics Education; *Problem Solving; *Teaching Techniques; Units of Study
IDENTIFIERS	*Mathematical Problem Solving Project

ABSTRACT

The development of three problem-solving modules is described and the formative evaluation activities for each module reported. The modules were: (1) Using Guesses to Solve Problems; (2) Using Tables to Solve Problems; and (3) Organizing Lists. Each module consists of a student booklet and a problem deck. Each contains problems coded for difficulty level. For each module this report discusses the development of the module, the formative evaluation design and results, and the revisions that were made in the module. (MP)

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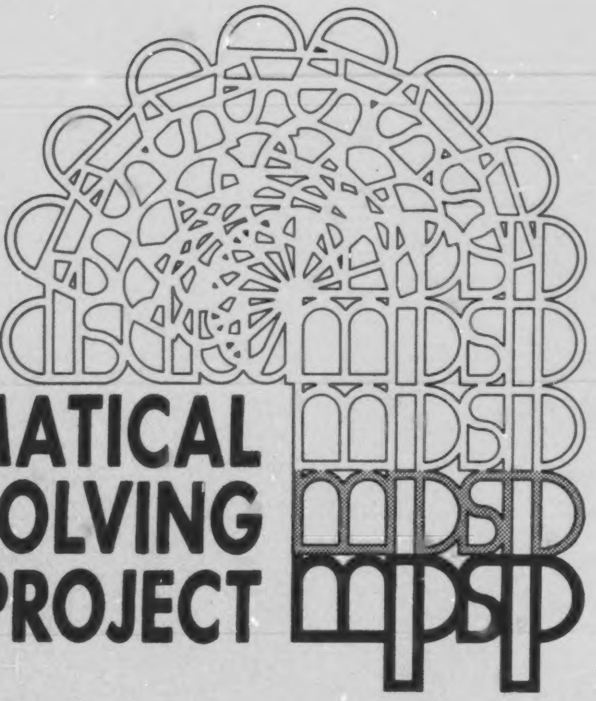

MATHEMATICAL PROBLEM SOLVING PROJECT

A Project of the
MATHEMATICS EDUCATION DEVELOPMENT CENTER

Project Supported by
National Science Foundation Grant PES74-15045

SE 026 916

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FINAL REPORT
MATHEMATICAL PROBLEM SOLVING PROJECT
TECHNICAL REPORT III:
MODULE DEVELOPMENT AND FORMATIVE EVALUATION

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May 1977

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INTRODUCTION

The Mathematical Problem Solving Project (MPSP) was co-sponsored by centers at the Mathematics Education Development Center (Indiana University), the University of Northern Iowa, and the Oakland Schools, Oakland County, Michigan. The primary goal of the project was to explore means for improving the problem-solving abilities of children in grades 4, 5, and 6.

During the 1974-75 and 1975-76 school years three problem-solving "modules" were developed by the MPSP staff. The titles of the modules and the MPSP center that developed the module are:

1. Using Guesses to Solve Problems, University of Northern Iowa;
2. Using Tables to Solve Problems, University of Northern Iowa;
3. Organizing Lists, Oakland Schools, Michigan.

A problem-solving module consists of two parts: a student booklet and a problem deck. The purpose of the student booklet is to give students selected experiences that facilitate solving problems using a particular problem-solving tool or strategy. For example, in the module titled Using Tables to Solve Problems two of the lessons are concerned with "completing a table" and "reading tables." The purpose of the problem deck is to give students practice solving problems (after completing the instructional booklet) in which a particular problem-solving tool or strategy can be used to obtain a solution. For all three modules, the problems in the decks are color-coded to indicate the difficulty level so that students of all ability levels could find some success with problem solving in the deck. For the modules Using Guesses to Solve Problems and Using Tables to Solve Problems the problem deck is divided into five levels of difficulty. For the module Organizing Lists, the problem deck is divided into three levels of difficulty. Table 0 shows the scheme used for coding the problem deck for each module. All three modules (instructional booklet and problem deck) are included in Technical Report II.

Table 0

Color-Coding Scheme for Each Module's Problem Deck

Module	Difficulty Level Easiest				Most Difficult
UG[a]	Blue	Yellow	White	Red	Green
UT	Blue	Yellow	White	Red	Green
OL	Blue	--	White	--	Green

[a] UG - Using Guesses to Solve Problems
UT - Using Tables to Solve Problems
OL - Organizing Lists

Each problem-solving module was involved in at least one trial during the 1975-76 school year in the Oakland County Schools. The formative evaluations of these trials were conducted by the MPSP staff at Indiana University and the Oakland Schools. The findings from the formative evaluations were used for subsequent revisions in the modules. This document is a report of the module development and formative evaluation activities for the MPSP problem-solving modules. For each module, this report discusses the development of the module, the formative evaluation design and results, and the revisions that were made in the module.

Finally, given below is a chronology of the development activities for the three modules discussed in this report.

Chronology of Module Development Activities

Fall, 1974 - Lists of tools and strategies prepared.

- Exploration of elementary children's problem-solving processes by interviewing students.
- Ten teachers recruited to participate in the trials of the materials and are in-serviced.
- U.N.I. focuses on guessing and testing and begins assembling problems and formulates plan for a module.
- Oakland Schools Center chooses organizing lists as topic for module and begins formulating idea of its form.

Winter, 1975 - U.N.I. presents the material on Guess and Test module to the teachers at Oakland Schools.

- Oakland Schools Center and teachers conceptualize and collect problems for the Organizing Lists module.

Spring, 1975 - Feedback is received from teachers on the Guess and Test materials.

- Problems for the Organizing Lists module are tried in the schools by project teachers.

Summer, 1975 - Teacher workshop held at Oakland Schools attended by 10 first-year project teachers and 19 new project teachers.

- Guess and Test module revised and called Introducing Estimation.
- First draft of Organizing Lists module is written by Oakland Schools Center.
- Developmental work on Using Tables to Solve Problems module begins at U.N.I.

Fall, 1975 - Wagon Wheel Workshop is held and attended by all project staff. Feedback is given on each of the modules: Organizing Lists, Introducing Estimation, and Tables. Objectives are clarified and sample items are suggested for the evaluation of the module.

- First trial of the Organizing Lists module, October 22 to December 3, using 19 classes.
- Trial of Introducing Estimation module, November 4 to December 16, using 11 classes, 8 new teachers and 3 old teachers.
- Trial of Introducing Estimation module in Malcolm Price Laboratory School at U.N.I.
- Tables module prepared by U.N.I.

Winter, 1976 - Feedback from trial data given to the writers of each module from the other two centers.

- Organizing Lists revised by Oakland Schools staff.
- Using Estimation revised by U.N.I. and called Using Guesses to Solve Problems.
- First trial of Using Tables to Solve Problems module, February 4 to March 17, using 8 classes.
- Second trial of Organizing Lists module, February 17 to March 30, using 9 classes.
- Trial of Using Guesses to Solve Problems, February 18 to March 31, using 9 classes.

Spring, 1976 - Editorial revisions made in Using Tables to Solve Problems and Using Guesses to Solve Problems.

- Trial of Using Tables to Solve Problems module, May, by 18 classes.

- Trial of Using Guesses to Solve Problems module, May, by 8 classes.

Summer, 1976 - Formative evaluation information for each module is synthesized and used to revise modules.

Fall, 1976 - Final revisions of modules.

A. FORMATIVE EVALUATION DESIGN

1. *General Design*

The formative evaluation design was developed to be appropriate for all three modules. Table 1 shows the major questions to be answered by the formative evaluation, the sources of evidence for the answers, the instruments that were used to collect the evidence, and when an instrument was used.

At the Wagon Wheel Workshop in September 1975, representatives from each project site agreed upon the major questions. The evaluation staff identified sources where evidence should be collected to determine if adjustments in the modules were necessary with respect to each major question. For each source of evidence instruments were developed to collect the evaluation data.

Table 1 shows that most of the evaluation instruments were used to gather data for more than one of the major questions. The 13 instruments used in the evaluations were:

Teachers

1. Teacher's booklet (with comments)
2. Teacher's problem deck (with comments)
3. Time-record, instructional booklet
4. Time-record, problem deck
5. In-service tape recordings
6. Interview questionnaire
7. Lesson rating form
8. Teacher debriefing questionnaire (for instructional booklets)

Project Staff

9. Instructional module (with comments)

(continued after Table 1)

Table 1

Ingredients of the Formative Evaluation

Major Questions of the Evaluations	Sources of Evidence	Instruments and When Collected
What implementation strategies are appropriate for the instructional modules?	Teachers	1[a]-A[b] 2-A 3-A 4-A 5-B 6-C
	Students	11-A
	Project Staff	10-D
Is the organization and content of the modules appropriate for the intended population?	Teachers	1-A 2-A 5-B 6-C 7-A 8-B
	Project Staff	9-E
How effective are the instructional modules?	Teachers	5-B 6-C
	Students	13-E 12-A

[a] 1 - Teacher's booklet (with comments)
2 - Teacher's problem deck (with comments)
3 - Time-record, instructional booklet
4 - Time-record, problem deck
5 - In-service tape recordings
6 - Interview questionnaire
7 - Lesson rating form
8 - Teacher debriefing questionnaire
9 - Instructional module (with comments)
10 - Observation schedule
11 - Student problem deck records
12 - Student work (sample)
13 - Quizzes (for each of the three modules)

[b] A - During or at the end of each day's instruction
B - At the action research sessions
C - May, 1976
D - During classroom observations
E - Not relevant

10. Observation schedule

Students

11. Student's problem deck records

12. Student work (sample)

13. Quizzes

    a. Using Organized Lists to Solve Problems

    b. Using Tables to Solve Problems

    c. Using Guesses to Solve Problems

Six of the instruments did not require any development activities by the evaluation team: 1, 2, 5, 9, 10 and 12. The observation schedule was an open-ended instrument on which observers (the project staff) recorded any comments related to the implementation, organization and content, and effectiveness of the modules. As a result of the first field test, the quizzes for the "organized list" and "guessing" modules were revised. Appendix A contains all of the instruments that were used in the evaluations.

Although considerable planning went into the development of every instrument, priority was given to the development of the module quizzes. In an effort to identify any weaknesses in the quizzes (e.g., readability) for the "guessing" and "tables" module,both were tried in Bloomington, Indiana schools with approximately 60 fifth-grade students prior to their use in the evaluation. For the "organized lists" module, the brief amount of time between the completion of the item development and the date for administering the quiz did not allow the instrument to be tried prior to its use. However, an item analysis at the end of the first field test of the module enabled the evaluation staff to revise the instrument for the second field test. The item development for the quizzes was performed for the most part by the evaluation staff at Indiana. For the "guessing" quiz, a member of the module development staff at the University of Northern Iowa assisted with the writing and selection of items. Although the assistance of the module developers was not used for the development of the other quizzes used for the evaluations, each quiz item was later examined and approved by the module developers.

The quizzes were developed for two purposes:

(1) to be used as a tool by the project staff for assessing the effectiveness of the modules for the formative evaluation, and

(2) to be used as a tool by the teacher for assessing student growth; that is, the quizzes are to be one part of the final version of the instructional module that is given to the teacher.

The evaluation staff concentrated on the first of these purposes during the year. Face validity of the quiz items was established. Additional, planned validity and reliability checks were not completed before the termination of the project.

2. *Population*

The modules were tried in the classrooms of the Oakland Schools. The Oakland Schools form an intermediate school district in Oakland County, Michigan. The student population of about 265,000 comes from a cross section of economic, social and ethnic backgrounds living in both urban and rural areas.

In the summer of 1974, letters were sent to certain school districts in the county asking if the district wanted to participate in MPSP and, if so, for a recommendation of a teacher who would be willing to be involved. Ten teachers participated during the 1974-75 academic year. Nineteen more teachers were added for the second year (1975-76). An attempt was made to have an equal number of teachers at each grade level. Of the twenty-nine teachers who were associated with the project, one dropped out and two, one a curriculum coordinator and one a principal, did not have any students to work with the second year. All of the remaining twenty-six project teachers came from different elementary schools. A few of the teachers were in charge of the teaching of mathematics at their schools in their grade levels. Most of the teachers had no special training in mathematics, and some had very little mathematics background.

A group of nine volunteer teachers, three at each of grades 4, 5, and 6, were used as a control group for the summative evaluation. Some of these teachers were from the same schools as some of the project teachers. A few of these control teachers administered some of the module quizzes to provide baseline information.

The project teachers were divided into three groups. Group 11 contained the eight teachers who remained with the project from the first year. The new teachers were divided into two groups, group 12 and group 13, so that each group had teachers at each grade level. Table 2 gives the teacher number, the grade level taught, the class size, and the general economic region for the school for each teacher.

Nearly all of the classes contained a range in ability level. Teacher 22 was the only teacher who reported having mostly slower students. Overall, the population used to test the materials contained from low to high-ability level students from lower to upper economic regions with a racial mix.

3. *Data Collection*

Four in-service sessions were held for each module at the Oakland Schools center. The purpose of the first session was to orient the

Table 2

Grade Level, Class Size, and Social-Economic Status of School Region for Participating Teachers by Group

Teacher Number	Grade Level	Class Size	SES
		Group 11	
28	5	29	Mixed
08	5	27	Upper-Middle
29	5/6[a]	16/16[b]	Upper-Middle
05	5/6	9/18	Mixed
24	6	28	Lower-Middle
18	6	55[c]	
01	6	28	Upper-Middle
09	6	28	
		Group 12	
27	4	27	Upper-Middle
30	4	30	
19	4/5	14/28	
06	4/5	8/19	
04	5	28	
02	5	27	
21	6	27	Mixed
17	6	19	
20	6	31	Upper-Middle

[a] 5/6 - Split class with fifth and sixth grade students.

[b] 16/16 - 16 students in grade 5 and 16 students in grade 6.

[c] Teacher 18 taught math to two classes.

Table 2 (Cont.)

Grade Level, Class Size, and Social-Economic Status of School Region for Participating Teachers by Group

Teacher Number	Grade Level	Class Size	SES
		Group 13	
40	3/4	11/12	
03	4	28	Middle
13	4	27	
23	3/4/5	10/10/10	Lower
15	5	32	Mixed
11	5	28	
22	5	16	
26	6	27	
14	6	31	
Total Students	754		

teachers to a) the goals of the module, b) the content of the module and c) possible teaching and classroom management strategies which might be appropriate. At this session the teachers received all teacher and pupil materials that were part of the module. The main purpose of the remaining three sessions was to obtain evaluative feedback from the teachers.

More specifically, the purpose of the second session was to obtain feedback on the "instructional booklet" phase of the module. The third session was devoted to feedback on the "problem deck," and the last session involved gathering feedback about the module as a whole as well as verifying feedback from the two previous sessions.

Each in-service session involved the distribution of evaluation materials and/or the collection of data. A list of the evaluation activities that were performed at each of the four sessions follows.

Session I: In-service and Distribution of Evaluation Materials

1. "Teacher's Instruction Sheet - Evaluation" was given to the teachers explaining the evaluation activities they would be participating in.
2. Seven evaluation instruments were distributed and explained to the teachers. (Eight were given if a pretest was used.)
    a. Teacher's booklet (for comments)
    b. Teacher's problem deck (for comments)
    c. Time-record, instructional booklet
    d. Time-record, problem deck
    e. Lesson rating form
    f. Student problem deck records
    g. Student work forms
    (h. Quiz: pretest for module)

Session II: Instructional Booklet Debriefing

1. Instruments a, c, and e above were collected.
2. The teacher debriefing questionnaire was completed.
3. Teacher feedback was obtained orally for a list of discussion questions.
4. The session was tape recorded.
(5. The pretest was collected.)

Session III: Problem Deck Debriefing

1. The post-test for the module was distributed.
2. Teacher oral response to a list of discussion questions was obtained.
3. The session was tape recorded.

Session IV: Module Debriefing

1. Instruments b, d, f, and g above were collected.
2. The post-test was collected
3. Teacher oral response was obtained to a list of discussion questions.
4. The session was tape recorded.

The general evaluation design indicates which evaluation question(s) the instruments were developed for. The general evaluation design also includes three instruments that were not involved with the in-service sessions. The "interview questionnaire" was used in May 1976, when most of the teachers were interviewed individually after Trial II. The observation data and the instructional module with comments, completed by the project staff, were returned to the evaluators near the date of the last in-service session. All of the instruments, together with the "Teacher's Instruction Sheet - Evaluation" and the "discussion questions," are included in Appendix A.

Some data was missing for every module evaluation for various reasons:

- Some teachers did not attend all in-service meetings and did not return the forms that were to be completed.
- Some of the instruments (e.g., pretests) were not completed in time for the trial.
- Samples of student work were not obtained for the first trial of some modules.
- Some of the teachers lost their evaluation data (e.g., student problem deck records).

B. ORGANIZING LISTS

1. *Description of the Module*

The module titled Organizing Lists was involved in two trials at the Oakland Schools during the 1975-76 school year. This section reports on the development and the formative evaluation of the module. Included in this section are

- Description of the Organizing Lists Module
- Evaluation Design
- Analysis and Results
- Summary and Recommendations.

Given below is an outline of the main events, in chronological order, related to the evolution of the Organizing Lists module:

Fall, 1974	- Oakland Center staff chooses organized listing for the topic of their module.
Winter, 1975	- Oakland Center staff and group II project teachers begin conceptualizing and collecting problems for the module.
Spring, 1975	- Problems are tried out in schools by project teachers.
Summer, 1975	- First draft of module, instructional booklet and problem deck, is written and compiled by Oakland Center staff.
Fall, 1975	- At Wagon Wheel Workshop feedback was given by other two centers on the Organizing Lists module. Objectives are clarified and sample items are suggested for the evaluation of the module. - First trial of the module, October 22 to December 3.
Winter, 1976	- Evaluation data from first trial was analyzed. - Feedback was given to the Oakland Center staff from the other two centers. - Second trial of module, February 17 to March 30.

Spring, 1976 - Evaluation data from second trial analyzed.

Summer, 1976 - Module revised and put in final form. Evaluation report begun.

Winter, 1976 - Evaluation report prepared by Indiana center.

The goal of the Organizing Lists module is to provide children with a tool they can use to help organize information, exhaust possibilities, and determine the correct solution for certain kinds of problems. The purposes of the instructional booklet and problem deck used with the first trial were:

1. to demonstrate the value of organizing information;
2. to establish the value of making complete lists as a problem-solving strategy;
3. to provide an opportunity for the children to become independent in using lists to solve organized list problems; and
4. to provide the children with practice in solving organized list problems.

Based on the first trial, the module was revised. The purposes of the revised version are to have the students:

1. read and organize lists;
2. make headings and entries in lists;
3. solve problems where the list is the solution and where the solution is contained in the list;
4. perform calculations on list entries;
5. solve problems when the list suggests relationships; and
6. solve problems using tree diagrams.

The first version of the Organizing Lists module included a teacher's booklet and a problem deck. In the booklet were four activities, each with a problem set, which the teacher could present to the students.

After completing the activities in the booklet, the students worked on problems in the problem deck. The Organizing Lists module was initially conceptualized to be highly teacher-directed. Some reasons for this decision were:

1. School districts may not be able to afford producing booklets for each student.
2. By giving the teacher more influence and direction, decisions can better be made to adjust the materials to the needs of the class.
3. If each student is given a booklet, the volume of materials required to implement the module might intimidate some teachers.

In response to the first trial, a consumable student booklet was prepared for the second trial, along with a teacher's edition and problem deck. The student booklet has six lessons. Two of the lessons are divided into two parts, A and B, one for fourth-grade students (A) and one for fifth- and sixth-grade students (B). Transparencies were included for each lesson in the teacher's edition. These could be used by the teacher to emphasize particular points of the lesson to the entire class at one time.

The problem deck for Organizing Lists is arranged into three colors - blue, white, and green. Each color represents a level of difficulty with the blue cards being the easiest and the green cards being more difficult. There are 21 blue problems, 16 white problems, and 21 green problems. In both versions, each lesson and activity was designed to take approximately one class period to complete. In the first version the teacher was to present a problem and then have the students work the problem and answer questions about the solution. The students could work individually or in small groups. For the second version the same procedure was to be followed except the students had the problems written and were to do their own work in the student booklet. A more detailed teaching procedure for each lesson was included in the teacher's edition for the second trial than was given in the first instructional booklet.

2. *Evaluation Design*

a. Instruments Used: The evaluation of the Organizing Lists module for both trials was conducted under the general design of the formative evaluation given in Chapter A. Data was collected to help refine the module in three major areas:

1. organization and content,
2. implementation, and
3. effectiveness.

All instruments used to collect data for each trial are given in Table 3.

b. Teacher Experience: Group 11 teachers had given a version of the "guessing" module to their classes in the spring of 1975. They were familiar with the format of the module and with using a problem deck. Group 12 teachers had no experience with any of the MPSP materials, except for the June workshop, prior to their trial of Organizing Lists. Group 13 used the Introducing Estimation* module for its first trial prior to giving the Organizing Lists module in February, 1976.

Table 4 gives the number of teachers at each grade level for each group and each trial.

---

* The name of this module was changed in revised versions to Using Guesses to Solve Problems.

Table 3

Number of Classes Using Each Instrument in Trials I and II

Instrument	Number of Classes Trial I (N=16)	 Trial II (N=9)
Time record - instructional booklet	0	9
Time record - problem deck	9	8
Lesson rating	13	9
Teacher interviews	14	6
Teacher debriefing questionnaire	13	9
Teacher's booklet with comments	7	0
Teacher's problem deck with comments	7	0
Student pretests	0	9
Student post-tests	16[a]	9
Student records - problem deck	10	8
Classroom observations	6	0
Student work (sample)	1	8
In-service sessions notes[b]	X	X

[a] 8 given after the instructional booklet. The other 8 given after working on the problem deck.

[b] Notes were either taken at the in-service sessions or the sessions were recorded on tape. Information was collected at in-service sessions for both of the trials.

c. Student Quizzes: Two forms of a quiz for the Organizing Lists module were constructed for the first trial and modified for the second trial. For the first trial each form had four problems, each of which was designed to measure one of six student performances:

1. Given a complete list, the student will be able to get information from the list.

Table 4

Number of Classes by Grade Level and Trial

	Trial I		Trial II
Grade Level	Group 11	Group 12	Group 13
3, 4			1
4		2	2
3, 4, 5			1
4, 5		2	
5	2	2	3
5, 6	2		
6	4	3	2

2. Given a partial list, the student will be able to find the rule and then complete the list.
3. Given a list, the student will be able to determine if the list is complete.
4. Given a problem and the framework (scheme) of a list, the student will be able to generate a rule and provide a list.
5. Given a problem where the student is told to use a list, the student will use the list to solve the problem.
6. Given a problem that can be solved by using a list, the student will be able to solve the problem.

The two forms of the quiz are given in Appendix B. The items written to measure each objective are:

FORM A		FORM B	
Item	Objective	Item	Objective
1	1	1	2
2	4	2	3
3	5	3	6
4	6	4	5

For the second trial some modifications were made in the quizzes. Students were having little difficulty working items 1A and 2B correctly. These items were not providing much information and were deleted for the second trial along with item 4A. Three additional performances were measured:

7. Given a problem where all possibilities must be exhausted, the student will find all of the answers. (Replaces objective 3)
8. Given a problem where a list can be made and the solution is one of the entries, the student will find the answer.
9. Given a problem where a tree diagram is applicable, the student will find all the possibilities.

FORM A		FORM B	
Item	Objective	Item	Objective
1	4	1	2
2	7	2	7
3	8	3	8
4	5	4	6
5	9	5	5

The answer for each item in the quizzes was scored right or wrong. For the open-ended items where the answer contained more than one part, the number of correct parts was counted. Other dimensions that the open-ended items were scored on were:

List - Did the student make a list? yes (1), no (0)

Complete - If the student made a list, was it complete? yes (1), no (0)

Heading - If the student made a list, was there a heading and was it adequate? no (0), partially (1), yes (2)

Organized - If the student made a list, was the list completely organized (2), partially organized (1), or without any organization (0)?

Structural Error - Did the student make an error in understanding of the problem? yes (1), no (0)

Executive Error - Did the student make a mechanical error in manipulation or calculation? yes (1), no (0)

The quizzes for Trial II were given as a pretest before any work was done in the instructional booklet and as a post-test, approximately six weeks later, after work in the problem deck was completed. Each student worked the same form for both the pre-and post-tests. The quizzes were not available in time to give as a pretest for Trial I. Instead, for Trial I the teachers were randomly divided into two groups. One group gave the quiz after completing the instructional booklet and before starting with the problem deck. The second group gave the quizzes after finishing work on the problem deck. This was done to get a feeling for the effectiveness of different parts of the module.

3. *Analysis and Results*

a. Analysis of Implementation of Module: This section is concerned with how the teachers implemented the Organizing Lists module and with the insights gained concerning the different ways of implementing the module. A discussion of the in-service sessions that were held for the teachers follows in order to indicate the context in which the teachers implemented the module.

i. In-service meetings. The first in-service meeting in each trial was devoted to giving the materials to the teachers and explaining how they could be used. The materials distributed included:

1) instructional booklets;
2) problem deck cards in a metal box;
3) student quizzes.

For Trial I, with the teacher-directed instructional booklet, the teachers were told that they did not have to do all of the problem situations. The teachers could select two or three situations and develop these thoroughly. The teachers had the option to decide which mode, individualized or small-group, they preferred to use to implement the instructional booklet.

For Trial II, with the student instructional booklets, the teachers were more restricted with what they could do. The booklet had six lessons with lessons 3 and 6 each divided into two parts, A and B. Fourth and lower fifth grade classes were instructed to cover the materials in lessons 1, 2, 3B, 4, 5, and 6B. The Oakland Center staff strongly recommended that after lesson 1 only one day be spent for each lesson. The teacher's edition of the instructional booklet discussed in detail, for each lesson, the objectives, materials to be used, and teaching procedures.

Some time at the second in-service meeting was spent talking about the implementation of the problem deck. The specifics of how the deck was to be used were left for the teachers to decide. The general recommendation was to use small groups. Besides having the staff explain the use of the materials, the in-service sessions provided the teachers with an opportunity to discuss what they did in their classes. This meant the teachers benefited from what was successful for other teachers. The teachers in Trial II also had the benefit of experience from using the deck with the Estimation* module in the previous trial. This seemed to have some effect on how they implemented the deck for this module.

ii. Implementation of the booklet. Information is available from five of the teachers in Trial I concerning how they used the instructional book. Four of these teachers gave an introduction to the activity to the class as a whole and then had their students work individually or in groups, on the remaining problems for that activity. The other teacher did most of the work at the chalkboard. For three of the five teachers, working with the class as a whole was different from the format in which they conducted their regular mathematics classes.

None of the teachers finished the booklet within a week with most taking between one and two weeks to complete the four activities. One reason for this was that the teachers were doing all the problem situations rather than the recommended two or three for each lesson. For example, one teacher made a sheet which listed every problem of each lesson. The students checked off each problem as they worked it. Each day was spent working on three or four problems.

In contrast to Trial I, in Trial II the teachers had previously implemented other modules and were familiar with the procedures. They were more familiar with problem decks and knew what was needed to prepare their students to work with a deck. For Trial II the teachers received a teacher's edition and a consumable student booklet for each student. Even though the students had their own booklets, the teacher had a major role in directing the students' work. The student booklet was used as a workbook where the students worked on problems and answered questions rather than for programmed instruction or as a textbook.

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* Later titled, Using Guesses to Solve Problems

Five of the nine teachers in Trial II presented the materials to the class as a whole and then had the students work exercises and problems individually or in small groups. Three teachers had their students work in small groups all of the time. One teacher had his class work individually. The grouping procedures used by each teacher were very similar to the grouping procedures used for the regular mathematics class.

Table 5 gives the number of class sessions used for each lesson by each teacher in Trial II. The sequence of lessons each teacher followed can also be observed in Table 5. In most cases the teachers followed one of the two recommended sequences.

Table 5

Class Sessions Per Lesson
Trial II

Teacher Number	Grade	Lesson 1	2	3A	3B	4	5	6A	6B
40	3/4	3	1	1	--		1	1	--
03	4	1	1	1	--	--	1	1	--
13	4	2	1	1	--	--	1	1	--
23	3/4/5	3	2	3	2	2	--	--	--
15	5	1	1	--	1	1	1	--	1
11	5	1	1	1	--	--	1	1	--
22	5	2	2	1	--	--	1	1	--
26	6	2	2	--	1	1	1	--	1
14	6	2	1	--	2	3	3	--	3
Mean-All Grades		1.89	1.3	1.3	1.5	1.75	1.25	1.0	1.67

The booklet was designed with the intent that each lesson would take one class session. Most teachers took more time than this for lesson 1 for such reasons as:

1. Some time was needed to introduce the module;
2. Some time was needed to explain the new vocabulary; and/or
3. Shorter periods were used. (For example, teacher 26 spent less than 45 minutes on lesson 1 but used two sessions.)

After lesson 1 (as recommended by the Oakland Center staff) most teachers used one session per lesson. In order to do this, however, some teachers felt pushed and had to omit material.

Table 6 gives the amount of time spent on each lesson by each teacher in Trial II. More time was spent on lesson 1 by most of the teachers than on any of the other lessons. Fourth-grade classes spent more time on lessons 2, 3A, and 5 than fifth- and sixth-grade classes even though they spent only one session on each lesson. The time spent on each lesson does not seem to depend heavily on the ability level of the students but it does seem to decrease with grade level. At least five of the teachers had a wide range of ability levels in their classes. Of the two teachers who spent the greatest time on the booklet, one (teacher 23) had students at a wide range of abilities from a culturally deprived area and the other (teacher 14) had students with average to low math abilities.

iii. Implementation of the problem deck. Each teacher used his/her own procedures for implementing the problem deck. Teacher 24 put the cards on a table in small stacks and let the students select which stack they would try to work. Teacher 20 randomly handed out cards the first few days and then let the students select cards by themselves. Teacher 27 had the cards available all day and had her

Table 6

Time Per Lesson
Trial II

Teacher Number	Grade	Lesson							
		1	2	3A	3B	4	5	6A	6B
40	3/4	5[a]	3	3	--	--	3	1	--
03	4	2	2	3	--	--	1	1	--
13	4	4	2	2	--	--	2	2	--
23	3/4/5	5	4	5	4	4	--	--	--
15	5	2	1	--	1	2	1	--	2
11	5	2	1	2	--	--	1	2	--
22	6	2	1	2	--	--	1	1	--
26	6	1	1	--	1	1	1	--	1
14	6	4	1	--	4	4	3	--	5

[a] 1 1-45 minutes
2 46-60 minutes
3 61-75 minutes
4 76-100 minutes
5 100+ minutes

students work the problems in a specially prepared notebook. All the notebooks were checked by her either daily or every other day. Teacher 02 prepared answer sheets for each problem and marked the student's work with a "+" if correct or a "-" if incorrect. The "-" was then changed to "+" when the student correctly solved the problem. A few teachers used a little more control over their classes by working problems with the group as a whole at the start of each session or restricting the students to a particular color for a given time period. Two teachers selected cards for students on the basis of the difficulty level of the problem and the ability level of the students.

Checking of the problems was handled in different ways. Most often, the work on a problem was brought to the teacher by the student or a group of students and was checked by the teacher. Sometimes, if the problem was not correct, students were asked to try again. One teacher had the students write their work on the chalkboard and spent the last fifteen minutes of the period having students explain their work. Another teacher randomly selected one student from the group to explain the problem and solution. In another class, one student was assigned as "checker" for the day and was given the problem deck with the answers. One teacher reported giving clues if the group was unsuccessful the first time and wanted to try again.

The time spent on the deck varied from class to class. A few teachers only allowed students to use the problem deck during their free time or after regular work was completed. In these situations, a few students never had an opportunity to work on the deck. Teacher 06 reserved 1 1/2 hours on Friday afternoons to work only with the problem deck. The three Friday afternoons were the only time the students had contact with the problem deck. In general, the teachers whose classes spent the greatest amount of time with the deck were those who spent some period of time (20-40 minutes) almost daily. One teacher reported that 40 minutes seemed to be too long for his students. However, several of the teachers used time periods of 1 to 1 1/2 hours. Table 7 shows, for those teachers reporting, the approximate total time spent and the average time spent per day working on the problem deck.

The mean number of problems attempted at each level of difficulty for each teacher's class is also given in Table 7. Group 11 classes, whose teachers were in their second year on the project, tried more problems, on the average, than the other two groups. More blue problems were tried than problems in the other two colors. Slightly more white problems were tried than green. There is not enough evidence

Table 7

Total Time Spent on Problem Deck and Mean Number of Problems Tried by Student by Teacher

Teacher Number	Class N	Grade Level	Grouping Procedures	Approximate Total Time Spent (Hours)	Time/Day (Minutes)	Mean Number of Problems Tried[a]		
						Blue	White	Green
			Group 11 - Trial I					
28	29	5	SG[b]	--	--	--	--	--
08	26	5	SG	--	--	3	2	3
29	34	5/6	I	3.5	30	8	3	1
24	29	6	SG,I	--	20	10	4	4
18	55	6	SG	--	--	9	3	2
01	28	6	I	5.75	45	15	2	1
09	28	6	SG	4.0	25-60	3	3	4
			Group 12 - Trial I					
27	25	4	I	3.0*	60*	4	2	1
30	30	4	I	9.67	10-60	--	--	--
19	28	4/5	SG,I	3.5*	30-60*	7	2	1
06	27	4/5	SG	4.5	90	--	--	--
04	25	5	SG,I	--	20	3	3	2
02	19	5	I	--	--	4	1	0
21	27	6	SG	--	10-15	7	3	1
17	19	6	?	--	--	--	--	--
20	31	6	SG,I	--	--	--	--	--
			Group 13 - Trial II					
40	26	3/4	SG,I	5.5	30	7	2	1
03	29	4	SG	4.5	60	8	3	0
13	25	4	SG	6.0	60	8	0	0
23	29	3/4/5	SG,I	7.0	20-40	2	3	0
15	32	5	SG,I	3.0	30-40	6	4	1
11	27	5	SG	4.0	60	4	0	1
22	17	5	SG,I	--	20-30	4	0	0
26	27	6	--	3.75	15-20	--	--	--
14	32	6	SG	2.0	20-30	3	2	0

[a] The numbers have been rounded to the nearest whole number.

[b] SG - Small groups of 2, 3, or 4
I - Individually

* - Plus free time

-- - No information is available.

to indicate that one grade level tried more or less of the problems than another grade level. It is evident that there is a wide variance among teachers as to the number of different problems tried, with teachers 24 and 01 classes averaging 18 problems in the deck compared with an average of four problems by students in teacher 22's class. The ability level of the students probably had some effect. Teacher 22 had low-ability fifth-grade students and teacher 24 had sixth-grade students with a range in abilities. Within a class there is also a wide range of the number of problems tried by students.

iv. Observations and recommendations concerning implementation. In both trials both versions of the module seemed to be compatible with a variety of teaching styles. This flexibility seems to bode well for the dissemination of the module.

The teacher's edition of the module should include an explanation of where "organizing lists" fits into problem solving, the rationale for the module, and the organization of the booklet and problem deck. The in-service sessions served this function very well for the project teachers. If the module is used without in-service meetings, much of the explanation of the background of the module would be missing.

The module may need to start with a brief discussion of some of the vocabulary used in the module. Such an addition appears to be needed for at least the lower grades where more time is required to get started with the module.

The recommended time period for the booklet should be extended to cover more days. Since the materials were being tried in a testing situation, there were some time constraints that had to be adhered to. This time pressure was a concern of several teachers. The instructional booklet appears to be sufficiently flexible that parts of lessons could be worked on for parts of class periods over a longer period of time. For each example and problem the teacher's edition identifies what the students should learn from doing the example or problem. This makes the problem a self-contained instructional unit which could be used by itself.

The basic format of the module used in Trial II should be retained. Feelings of the teachers were mixed about having a module which is teacher-directed. This module seems to allow the teacher a greater opportunity to adapt the implementation of the module to her/his usual style. Teachers liked having a student booklet.

Some instructional or summative comments should be added to the student booklet after each lesson. If a teacher would like to use the booklet without as much teacher direction, such comments would be beneficial.

Due to the termination of the project, not all of the recommendations resulting from later trials are reflected in the modules.

b. Analysis of the Organization and Content: The organization of the Organizing Lists module was changed for the second trial from four activities to six lessons. The format was also changed by adding a student booklet. This section deals with the evaluation of the content and organization of both versions of the booklet and the problem deck.

i. Trial I. For Trial I the instructional booklet was organized into four teacher-directed activities. The purpose of each activity was:

Activity 1 - to demonstrate the value of organizing information using the second type of list (permits analysis which isolates possible solutions via classification).

Activity 2 - to have students create their own framework or scheme for making a complete list, and to establish the value of completion of lists as a problem-solving strategy. Students were given problem situations from which lists could be made and were asked questions which required them to use their lists to determine answers.

Activity 3 - to give students experience in solving problems, with the goal of student independence in solving organized list problems.

Activity 4 - to provide individual or team practice in solving organized list problems using a resource deck of problem cards. This activity was an informal evaluation of the previous activities.

Briefly, the activities were designed and ordered first to show a need for organizing information; second, to show how to make an organized list; and third, to provide experience in using organized lists to solve problems. In the comments gathered from the project staff, some question was raised as to whether these three lessons provided adequate preliminary experiences. Based on the experience of a preliminary trial of the module with small groups of students, it appeared that students need to learn about making a list before the organization of the list is discussed. In these early explorations, students had difficulty organizing three or more columns and deciding whether or not a list was complete.

The Oakland teachers' comments were concerned with editorial feedback and how the individual problems and examples seemed to work rather than with critiquing the objectives of the module. The sources of information from the teachers include the lesson rating form, the content and construction review, written notes on the booklet and problem deck, and comments made at the in-service meetings. There was general enthusiasm for the module.

Some of the concerns raised by the teachers in Trial I were:

1. Students had problems with the vocabulary, particularly at the lower grades.
2. Students did not know where to begin in solving a problem using organized lists. They had trouble with the framework and the headings.
3. There were not enough problems either in the booklet or the problem deck at a lower reading and difficulty level for slower students.
4. A student booklet would be useful. (This comment was made by several teachers who used a student booklet in Trial II of another module and were referring back to Trial I and the Organizing Lists module.)
5. More practice was needed in the booklet.

Table 8 gives the mean responses on the lesson rating forms by teacher group and grade level for each activity on each question. Group 11 teachers (second year on the project) felt the lessons were more appropriate for their students than did the group 12 teachers. There may be an interaction with grade level since most of the teachers in group 11 taught fifth- or sixth-grade classes and group 12 contained a fairly even distribution across grades 4, 5, and 6. Activity 1 was rated lower on overall purpose by group 11 teachers than the other two activities. Group 12 rated the activities about the same on overall purpose but at a lower level than did group 11. The rating of the usefulness of the teacher's notes varied by activity for each group. It should be noted that ratings of all but one activity by all these groups of teachers was 4.0 or above on a scale of 5.

Table 8

Mean Responses on Lesson Rating Form
by Teacher Group and Grade Level
Organizing Lists Module - Trial I

Group	Appropriate for Ability Level Activity			Appropriate for Overall Purpose Activity			Teacher Notes Activity		
	1	2	3	1	2	3	1	2	3
Teacher Group									
Group 11 N = 5	4.6[a]	4.6	4.6	4.2	4.8	5.0	4.0	4.3[b]	4.3[b]
Group 12 N = 8	4.0	4.1	4.3	4.5	4.6	4.7[b]	4.4	4.1	4.4
Grade Level									
Grade 4 N = 4	4.0	4.3	4.3[b]	5.0	4.8	5.0[b]	4.5	4.5	4.7[b]
Grade 5 N = 4	4.0	4.3	4.5	3.8	4.5	4.5	4.0	4.0	4.3
Grade 6 N = 5	4.6	4.4	4.4	4.4	4.8	5.0	4.2	4.0[b]	4.3[b]

[a] 5 - Appropriate; 1 - Inappropriate.

[b] Data is missing from one teacher.

For most of the activities, fourth- and fifth-grade teachers felt the activities were slightly less appropriate for the ability level of their students than did the sixth-grade teachers. Activity 1, which was rated the lowest, was still considered appropriate. The fifth-grade teachers felt the activities were less appropriate for the overall purpose of the module than teachers at the other two grades. Again, Activity 1 was rated a little lower than the other activities by fifth- and sixth-grade teachers, but all activities were rated high. The teacher's notes were rated more appropriate for the fourth-grade teachers than for the fifth- and sixth-grade teachers.

Below are the questions from the Content and Construction Review for which more than 25% of the teachers responding had a negative response. All other questions received more than 75% positive responses.

		Yes	No
Display and Format			
3.	Does the display layout avoid a crowded appearance?	9	4
Practice Opportunities			
6.	Does the product maintain a record of learner progress during practice?	4	7
Content Analysis			
1.	Have adjustments been made to the instructional program to accommodate learners of different aptitudes?	7	6
2.	Is there an indexing subroutine provided to facilitate access to specific topics in the product?	6	5
6.	Does the product avoid overemphasizing topics which do not merit detailed treatment?	4	8
12.	After a term or concept has been presented, is adequate practice provided for its application?	4	10
13.	Is review cumulative and appropriately spaced?	3	4
14.	Are self-checking materials built into the product at appropriate points?	5	6

		Yes	No
15.	Does the product avoid extreme variations in the difficulties of the content?	10	4
16.	Is the product likely to be challenging but not discouraging to the learner?	11	4
18.	Are new terms defined as they are introduced?	7	4

The booklet was written to use a minimum number of pages. This may be the reason why some of the teachers felt that there was a crowded appearance. The module itself does not provide for keeping records of learner's progress or self-checking. Some of the teachers devised their own systems such as having students use notebooks and then correcting the notebooks. Item 1, Content Analysis, points out that some teachers felt that learners of different aptitudes were not accommodated. Several teachers felt that the format of the booklet could be changed by highlighting the objective of the lesson and procedures to be followed. Also, some system to relate some of the problems in the deck to the activities was thought to be useful. Item 12, Content Analysis, provides a strong response that inadequate practice was provided after a concept was presented.

Editorial feedback for each activity is given in Appendix B. General comments for each activity are given below.

Activity 1. Some teachers experienced difficulty with this activity because of organizational problems. This was the first time some students had worked in groups. The social interaction required in this activity was somewhat distracting from the main objective. Some teachers liked the grocery store problem (problem 1) and some felt it was confusing. Some felt that a picture or map was needed to make this problem work.

Problem 2, the puzzle problem, went well for most. Some students did not like the idea of making a list for problem 4, the newspaper route. One teacher suggested giving a reason why a list should be made, for example, so a friend could deliver the papers.

If this is the first module given to the students, some problem with how to use the materials is expected. The problems in Activity 1 did provide an opportunity for students to start working together and getting ready to think about lists. More time may be needed at the beginning to get students thinking about lists. There were some comments that problems were needed in this activity that are solved by using a list.

Activity 2. Some teachers felt Activity 2 was much like Activity 1 and, in effect, provided more practice for the first activity. Students had problems deciding if a list was complete and had trouble developing the framework for a list. Changes that were suggested by teachers were:

1. Include more practice problems for slower learners and optional problems for advanced students.
2. Change either problem 2 or 3. These are too much alike.
3. Include some intermediate problems between problems 4 and 5.
4. Key cards in the deck to this activity.

Activity 3. Some of the same comments were made about Activity 3 as were made for the second activity. Namely, more practice and optional problems are needed. Some of the problems in Activity 3 (problems 2, 3, and 4) do not lend themselves to making a list. For these problems students used trial and error. The teacher-student problems had to be worked entirely with the teacher and students working together for some of the classes. Students still had problems with setting up the framework and getting started making a list. This activity did not prepare the students adequately on these points either.

ii. Trial II. For Trial II the instructional booklet was organized into six lessons. The teacher was still to have a major role in the presentation of the booklet even though a student booklet was included. Modifications that were made to the booklet based on information received from the first trial include:

1. A student booklet was included.
2. Objectives, materials, and teaching procedures were clearly identified at the beginning of each lesson.
3. Two tracks were formed - one for the lower grades, fourth and low fifth, and one for the upper grades.
4. Although to set up the framework for an organized list is not an objective of any of the lessons, more problems were included where students had to do the whole process from setting up the list to putting in the entries and finding the solution.
5. Lesson 1 includes problems with lists and asks students to read information from the lists.
6. More problems were included.
7. Transparencies were included.
8. A lesson on tree diagrams was added.

The purposes for the six lessons of the second version are:

Lesson 1: Given a complete list the student will
  (a) read and answer questions based on information in the list;
  (b) rearrange the list according to a specified criterion.

Lesson 2: Given a partial list and a problem situation the student will complete the list by writing missing headings and/or missing entries.

Lesson 3a: Given a problem situation and a list, the student will answer questions about the problem situation.

Lesson 3b: The student will solve problems using a list given a problem situation in which

(a) the list is the solution;

(b) the list contains the solution as specific entries.

Lesson 4: Given a problem situation with or without the list, the student will answer questions requiring calculations of entries in the list.

Given a problem situation, the student will inspect the list to find relationships that lead to solution.

Lesson 5: Given a problem situation and

(a) a complete tree diagram, the student will be able to answer questions using the diagram;

(b) a partial tree diagram, the student will complete the diagram;

(c) instructions to make a tree diagram, the student will construct the diagram.

Lesson 6a: The teacher will review the previous lesson objectives. The student will solve problems similar to the resource deck in preparation for its use.

Lesson 6b: Given a problem situation, the student will be able to solve the problem using both a "column" list and a tree diagram. The student will solve problems similar to the resource deck in preparation for its use.

The teachers in group 13 tried the module in Trial II. As in Trial I, the teacher's comments were generally favorable (see e.g., Table 9). Some comments and concerns raised by teachers about

Trial II include:

1. Transparencies seemed to work well when time was available.
2. Students did not have any starting point in making lists.
3. Students liked the idea of tree diagrams, but had difficulty finding everything.
4. Tree diagrams were too difficult for lower grades.
5. Taking just the lessons in the lower track caused trouble with the card deck. Not much work was given in this track on tree diagrams and on the use of the whole list as the solution.
6. Sports problems had high interest for students. Different sports could be used for variety, and something else could be added for teachers who are not into sports.
7. Some of the cards, one or two, could be done after each lesson. Some students became frustrated toward the end of the booklet.
8. The booklet was well-sequenced.
9. The lessons could use more content or problems.
10. More time needed to be spent on vocabulary for some students.

Table 9 gives the mean responses on the lesson rating forms for the teacher group and track for each lesson on each question. The overall responses were high. Lessons 4, 5, and 6a were felt the least appropriate for the ability level of the students for most of the teachers. The lowest rated lesson was Lesson 5, tree diagrams. Lessons 1 and 2 were rated lower on appropriateness for ability level by teachers who took the fourth-grade track than by the other teachers. Most of the lessons were rated high on appropriateness for overall purpose. Lessons 4 and 5 were rated the lowest. Only small differences existed between ratings of teachers in the two tracks. The teacher's notes were rated high on all lessons with lessons 3a, 5 and 6b being rated the lowest.

Table 9

Mean Responses on Lesson Rating Form by Teacher Group and Track Organizing Lists Module - Trial II

Lesson	Teacher Group Group 13 N = 9	Track Track 1 N = 5 (fourth grade)	 Track 2 N = 4[b] (5th and 6th grade)
		Appropriate for Ability Level	
1	4.6[a]	4.4	4.8
2	4.0	3.8	4.3
3a	4.3	4.4	4.0
3b	4.3	---	4.3
4	3.8	---	3.8
5	3.3	3.2	3.3
6a	3.6	3.6	---
6b	4.0	---	4.0
		Appropriate for Overall Purpose	
1	4.8	4.8	4.8
2	4.6	4.6	4.5
3a	4.5	4.6	4.0
3b	4.3	---	4.3
4	4.0	---	4.0
5	3.9	4.0	3.7
6a	4.6	4.6	---
6b	4.7	---	4.7
		Teacher Notes	
1	4.6	4.4	4.8
2	4.6	4.4	4.8
3a	4.0	4.4	3.0
3b	4.5	---	4.5
4	4.3	---	4.3
5	4.1	4.4	3.7
6a	4.2	4.2	---
6b	4.0	---	4.0

[a] 5 - Appropriate 1 - Inappropriate

[b] One fifth-grade teacher of this group took lesson 3a and did not take lessons 5 or 6b. The N was adjusted to account for this.

The teachers who took the fourth-grade track rated the teacher's notes for Lessons 1 and 2 lower than did the teachers in the other track.

The results of the lesson rating form reflect the feeling that there is still some problem in having material in the booklet appropriate for all ability levels, particularly, at the lower grade level. Lesson 5, tree diagrams, was consistently rated lower on all of the three questions and by teachers in both tracks.

On the Instructional Feedback Questionnaire nearly all of the teachers responded positively toward the module. The largest number of negative responses on any item was two (out of eight) and these were only on two questions:

- Does the material avoid extreme variations in difficulty?
- Are the instructions to the learner complete, clear, and easy to follow?

Editorial feedback on each lesson from the teachers is given in Appendix B. General comments on each lesson are given below.

Lesson 1: Students, especially boys, were interested in this lesson. The pictures and the use of sports added to their interest. One class had difficulty with vocabulary - column, row, lists, uses of organizing lists, headings, rank, organizing, and reorganizing.

Lesson 2: The problem on page 8 was stimulating, but students had some trouble with the problems on pages 9 and 10. Problem 1 on page 9 was confusing to some students and had to be explained at length. More questions could be added for problem 2 on page 9 to highlight for the students what they are to be learning. In one fifth-grade class the majority of the students had to be helped on problem 2, parking lots.

Lesson 3a: Students began to get the idea of a list during this lesson. They liked this lesson and, for one class, this was the favorite lesson. Problem 2 on page 14 went well in most cases if a reasonably-sized subset of classmates was chosen, ten or less.

Lesson 3b: In a mixed class of third-, fourth-, and fifth-grade students, everybody wanted to do this lesson. The class had trouble with problems 1 and 2 on page 18, but with the help of the teacher the students were able to understand the problem.

Lesson 4: One class had difficulty on problems 1 and 2 on page 22. Some of the trouble was with multiplication and column addition. Using a magic square whose product is less than 1000 would be helpful.

Lesson 5: This lesson was the most difficult. In one fifth-grade class this lesson was the only point where frustration was apparent. Many students began to lose interest. In two fourth-grade classes, students could not do complete tree diagrams on their own. Diagrams were messy for most. Two or three students did like this method and had fun. However, the majority of students in the class were confused and frustrated.

Lesson 6a: Lesson 6a brought back some of the interest lost with lesson 5. One teacher commented that having students visualize parts of a chair made them think.

Lesson 6b: Most classes who tried the problem on page 33, the shirt problem, had trouble with it. The tree diagram was too difficult for the students to handle at this point.

Problem Deck: The problem deck for the Organizing Lists module contains fifty-eight problems grouped into three levels of difficulty:

blue problem cards; 21 cards, easiest;
white problem cards; 16 cards, middle; and
green problem cards; 21 cards, most difficult.

The problem deck was not modified between trials.

General comments made by the teachers about the problem deck include:

1. The students enjoyed the cards and the cards had enough variety that almost everyone had some success.
2. Some cards should be written at a lower reading level. These cards then should be keyed so the teacher could have slower readers solve these problems.
3. More blue cards or cards at a lower difficulty level should be included. Some of the fourth-grade classes needed more practice but could not get through the white problems and were "floored" by the green problems.
4. Some hints should be given on the backs of the cards to help students get started with the problems. One teacher suggested some hints for several of the problems. These are included in Appendix B under Editorial Feedback - Problem Deck.
5. Fourth-and fifth-grade students who took the lower track were not prepared to solve some of the problems, in particular, the white and green problems.
6. Cards should be keyed to a lesson so teachers can find practice problems for a lesson if needed.

For the purpose of the content analysis of the problem deck, the problems were first partitioned into two general groups, list and non-list problems. The non-list problems are the problems where using a list to solve the problem is inappropriate. These non-list problems were included in order to give the students experience with deciding where to use lists. The list problems were further subdivided into two categories according to whether the problem required a whole list for the solution or one or two of the entries from the list as the solution. Then under each of these categories similar problems were grouped and labeled as a particular problem type. This categorization scheme and list of problems within each problem type is given in Table 10.

Table 10

Categorization of *Organizing Lists* Problem Deck into *Problem Types*

List Problems.

Whole List:

Type 1 - Ways to make change	B01,B019,B020,G04,G020
Type 2 - Number of routes	B02,B08,W015
Type 3 - Sum of digits, numbers	B03,B04,B012,G02,G03
Type 4 - Permutations	B06,B07,B013,B014,B018,W06,W014
Type 5 - Different shaped boxes	B017,G010

Subtotal of Whole List Problems - 22

Entry from List:

Type 6 - Number of coins and amount	B05,B011,W01,G01
Type 7 - Sum, difference of two numbers	B09,B010,W08,W016,G012,G014,G015
Type 8 - Dart board	B016,G017,G018
Type 9 - Magic square	W02,W04,W07,W013,G06,G07,G08
Type 10 - Least common multiple	W05,G05,G021
Type 11 - Linear transformations	W09,W010,W011
Type 12 - List and logic	G013
Type 13 - Likely event (dice)	G016

Subtotal of Entry-from-List Problems - 29

Non-List Problems.

Type 14 - Stamp arrangement	B015,B021
Type 15 - Crypto	W03,G011,G019
Type 16 - Fox-geese	W012,G09

Subtotal of Non-List Problems - 7

One purpose of the instructional booklet is to prepare students to solve problems in the problem deck. Comparing the problem types that were used in the booklet (Trial II) with those used in the deck, some differences exist. The problem types with the greatest number of items (problems and examples) in the instructional booklet were types 1, 2, 3, and 4. Each type was represented by at least three problems and at most five problems. All of these problems are "whole-list" problems.

Problem types 5, 6, 7, 8, 9, and 10 were each represented by one or two problems in the instructional booklet. With the exception of type 5, these problems are "entry-from-list" problems. Problem types 11 and 12, "entry-from-list problems", and the "non-list problems" were not represented in the instructional booklet.

The proportion of problem types in the deck does not exactly correspond to the proportion of problem types in the instructional booklet. The deck has a higher proportion of "entry-from-list" problems than "whole-list" problems.

Some problems are discussed and used in the instructional booklet that are not included in the problem deck. These are:

Distribution of n items into m containers
  Lesson 2, page 9, item 1
  Lesson 3b, page 17, item 1
  Lesson 5, page 27

Collect and then organize information into a list
  Lesson 2, page T(11), example B
  Lesson 3, page 14, item 2

All combinations, at most n events
  Lesson 4, page 23

Intersection of events (tree diagram)
  Lesson 5, page T(24) (similar to problem type 2)

Overall, the problem types in the deck correspond to the problem types used in the instructional booklet. There are a few problems that exist in one and not the other. Using a list is not very appropriate for seven of the problems in the deck. In the instructional booklet there are more "whole-list" problems than "entry-from-list" problems, whereas more "entry-from-list" problems are included in the deck.

The data concerning the number of students that selected each problem in the problem deck provided some evidence as to how the problem deck was used and the types of problems attempted by the students. Table 11 shows which problems were attempted by the greatest number of students and which problems were attempted by the fewest students. The number of students that selected each problem for each teacher group is given in Appendix B. Comparing the number of students that selected each problem at each level of difficulty across trials, the rank-difference correlation coefficients are:

.98 - blue cards
.93 - white cards
.98 - green cards.

These correlations, together with the data in Table 11, suggest that approximately the same number of students attempted the same problems at each level of problem difficulty for both trials of the module.

Table 11

Numbers of Problems Tried the Most and the Least for Each Trial by Color

Problem Color	Problems Tried the Most		Problems Tried the Least	
	Trial I	Trial II	Trial I	Trial II
Blue	BO[a] 1,3,6,2,7,10,9	1,6,2,3,7,4,8	17,21,16,11,20	21,17,16,15,11
White	WO 9,6,2,4,1	9,10,4,6,1	12,14,11,7	12,15,5,7
Green	GO 6,7,1,8,13	6,13,1	16,15,14,20,11	11,12,15,16,18,10
Total Number of Problems	17	15	14	15

[a] The problem numbers are written in order with the problem tried the most or least given first.

The teachers' feedback concerning how they implemented the problem deck revealed that several teachers tried a few of the blue problems with the whole class before letting the students select their own problems. This may be one explanation for the fact that the blue problems near the beginning of the blue-difficulty-level-problems were selected by a large number of students, while the blue problems near the end were not selected by many students. Although some teachers reported that their students selected problems from different locations in the deck, overall, the problems near the beginning of each level of difficulty (i.e., each section of colored cards) were selected by more students than the problems near the end of the difficulty level. This, of course, is what one would expect when students select their own cards. Table 11 shows, for example, the 17 problems for Trial I attempted by the greatest number of students. Table 12 shows the distribution of these 17 problems over the 16 problem types included in the deck. Similarly, Table 12 shows the distributions across problem types for the remaining "total number of problems" shown in Table 11.

For both trials students recorded on a record sheet or on their work page whether they liked or disliked the problem and whether they thought the problem was easy or hard. No problems in any color were consistently recorded as being hard or disliked by students in Trial II. For students in Trial I, very few responses of "hard" or "disliked" were recorded. The problems recorded as being liked by more students in Trial II were, in order, W09, B01, B02, and B04. These problems were also recorded as being easy, but by fewer students.

Problem W09, type 11, is a linear transformation problem where a list is used to record number guesses and the transformations of the number and then to compare the transformed number to a desired result.

Table 12

Distribution of Problems Tried the Most and the Least by Problem Type

	Problem Type	Number of Problems in Type	Number of Problems Tried the Most		Number of Problems Tried the Least	
			Trial I	Trial II	Trial I	Trial II
	1	5	1	1	2	0
	2	3	1	2	0	1
Whole List	3	5	1	2	0	0
	4	7	3	3	1	0
	5	2	0	0	1	2
	6	4	2	2	1	1
	7	7	2	0	2	2
	8	3	0	0	1	2
Entry-from List	9	7	5	2	1	1
	10	3	0	0	0	1
	11	3	1	2	1	0
	12	1	1	1	0	0
	13	1	0	0	1	1
	14	2	0	0	1	2
Non-List	15	3	0	0	1	1
	16	2	0	0	1	1

(For example, guess an age. Add 10 to it. Double that result. Is this equal to 82?) The work of the students who tried this problem in Trial II shows that these students used computation to solve the problem and not a list unless the list was suggested and set up by the teacher.

Problem G01, type 6, was one of the green problems solved by more students. Of the eight students whose work was available, five got the problem correct. Lists were not used except in a few cases where the headings were written down and the answer written underneath. Problem G06, type 9, was another problem tried more than other green problems. The work of the eleven students who tried this problem showed that no lists were written on the papers. Only the triangle with numbers was given.

iii. Recommendations for Organization and Content: In general, the organization and content of the module seem to be appropriate. The students found the problems interesting and challenging and the teachers were able to comprehend and follow the organization of the module. Some changes in the module that may be appropriate are the following.

1. Lesson 5 should be made optional for lower grades.
2. Some of the problems in Lesson 5 should be made less difficult (e.g., the shirt problem).
3. The problem deck should be increased and arranged by problem categories; one possible categorization is given in this report. More blue problems with some at a lower reading level should be added.
4. The problems in the deck should be keyed to particular lessons. If a teacher wants students to have more practice on a lesson, then the teacher can refer them to the problems in the deck.
5. Opportunity for more practice should be given for each lesson. This can be done either by adding more problems to the lesson or by referencing problems in the deck (see 4 above).
6. Some hints about how to get started should be included for some problems.
7. Teachers should be instructed to check for the use of lists when working with the problem deck. Some students are solving problems in the deck without using lists.

c. Analysis of Effectiveness: Two sources of data existed for assessing the effectiveness of the Organizing Lists module, teachers' comments and quizzes. Teachers' comments were collected at the interviews in May at the in-service meetings. In Trial I, quiz scores were obtained for half of the classes after completing the instructional booklet and before starting with the problem deck, and for half of the classes after completing the problem deck. In Trial II, quiz scores were obtained for all classes before the instruction began (pre-test) and after finishing work on problems in the deck (post-test).

i. Teachers' General Comments. Teachers in all three groups felt the time spent on Organizing Lists and the other modules was worth the effort. Only one teacher in group 13 expressed some doubt about the value of doing the Organizing Lists module. She was, on the other hand, enthusiastic about the Using Guesses to Solve Problems module.

Teachers felt their students learned how to make lists and that sometimes they would try to use lists. The students would not always include headings when using lists, but students knew what headings were. The biggest problem described by teachers in Trial I was that students had difficulty getting started making lists. Students had problems in isolating the parts of the problem, deciding what headings to use, and setting up the lists. The students could complete the lists if they were given the framework. The teachers in Trial II reported their students had some of the same problems, but this was not emphasized as much as by teachers in Trial I.

The teachers reported that some transfer of the use of organized lists to other situations and content areas besides math did occur but was small. Two or three teachers reported finding situations in science and social science where lists could be used. The teachers had not observed these before and felt they learned something about problem solving from the module. Other examples of transfer that were reported are:

- Students in one class, on their own, made a list to organize vocabulary words.
- Students in one class noted the similarities between listing and their other work, such as using a time line.
- One girl organized for her mother a list of medicines to be given to her sister.
- One boy used a tree diagram to describe a chess tournament.

Reports were mixed concerning the transfer of using lists to solve problems in the Using Guesses to Solve Problems module by students who had had the list module first. One teacher reported that none of her students even thought about using lists to do the guessing problems. Another teacher said some of her students did use lists on these problems.

Parents made comments to two of the teachers about how their children were enjoying math more this year than ever before. Some parents did inquire of one teacher when he was going to teach math. These parents said their children were enjoying math more and learning the skills, but wanted to know when the teacher was going to use the book again.

ii. Quiz Results. Two forms, A and B, of the quizzes were used in both trials. The same quizzes were given to all grade levels. The quizzes, module objectives, and which quiz item relates to which objectives are discussed in the Evaluation Design section of this chapter. For Trial I, two forms were used with four items in each form. Each item corresponds to one of the six objectives of the Organizing Lists module. The module was revised for Trial II and three more objectives were identified. The quizzes were changed so that some items corresponded to these objectives. One or two items were deleted from each form of the first set of quizzes because almost all the students were getting the items correct prior to any instruction (e.g., item 1A, Trial I) or because the item was too difficult (item 4A, Trial I). Each form of the quiz used in Trial II had five items.

The items on the quizzes were scored either right/wrong or by the number of correct responses for a multiple-answer item. On some items the following process variables were rated:

list - Is a list given on the student's paper?
complete - If a list is given, is it complete?
heading - If a list is given, does it have headings?
organized - If a list is given, is it organized?
structural error - Was an error in understanding made?
executive error - Was an error in manipulation or computation made?

Tables 13, 14, 15, and 16 give the percent correct out of the total possible scores for all items for each of the forms in each trial. Teachers were divided randomly into groups to give the quizzes before or after the problem deck in Trial I. For the sixth-grade classes the "post" problem deck classes scored higher on most variables. For the fifth-grade classes, the opposite was true. Results for the fourth-grade classes were mixed. There is no consistent evidence that having worked problems in the deck improved the scores on the quizzes. The differences appear to be due more to class differences than the effect of working problems in the deck.

In Trial II gains on correct answers were made between pretests and post-tests by all grade levels and for each item except for the fifth-graders on items 2B, 3B, and 4B. The use of a list increased, with the biggest change occurring on item 5B by the sixth-grade classes. For this problem the list can be the solution, and students were requested to use a list. On items 5A and 4B, where the students were asked to solve the problem but were not given specific instructions to use a list, the use of a list increased also but not as much as for item 5B. Nobody used a tree diagram on item 5A which was included because a tree diagram could be used. Scores on the multiple choice items: 2A, 3A, 2B, and 3B, increased in most cases, but were still under 50 percent for all but the sixth-graders on items 3A and 2B. The fifth-grade classes consistently scored lower on the post-test than the fourth-grade classes. The sixth-grade classes scored the highest. It should be noted that throughout the formative and summative evaluation the data from the fifth-grade classes paint a somewhat unclear and confusing picture.

iii. Objectives. The quiz results are discussed below with respect to each of the objectives for both trials.

Objective 1: Obtain information from a list (Item 1AI)*. Almost all students could get information from one column of a list. Over two-thirds of the students could derive information from the list when entries from two or three columns had to be used.

Objective 2: Find the rule and complete the list (1BI, 1BII). The sixth-grade classes gained the most on this item with nearly 90 percent of the sixth-grade students being able to find the rule and complete the list. Fourth- and fifth-grade classes gained some, but more than a third of these students did not get the item

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* 1AI represents item 1 on form A used in Trial I.

Table 13

Percent Correct of Total Possible Score on Items in Organizing Lists Quiz - Form A, Trial I by Pre- or Post-Problem Deck and Grade Level

Pre- or Post-Problem Deck	Item 1			Item 2					Item 3							Item 4						
	1a	1b	1c	Answer	Complete	Organized	Structural Error	Executive Error	Answer	List	Complete	Heading	Organized	Structural Error	Executive Error	Answer	List	Complete	Heading	Organized	Structural Error	Executive Error
Fourth Grade																						
Pre (N=1)[a]	92	61	77	60	8	27	85	15	54	46	31	12	38	38	23	0	15	15	8	12	85	0
Post (N=2)	100	65	73	68	27	31	77	8	31	62	50	8	60	15	19	27	38	35	4	37	46	12
Difference: Post-Pre[b]	8	4	-4	8	19	4	-8	-7	-23	16	19	-4	22	-23	-4	27	23	20	-4	25	-39	12
Fifth Grade																						
Pre (N=3)	98	80	90	72	39	50	51	15	58	22	10	3	17	22	15	20	32	29	3	32	68	5
Post (N=3)	92	65	68	51	3	33	68	27	27	27	24	0	27	24	3	5	11	5	0	8	76	3
Difference: Post-Pre	-6	-15	-22	-21	-36	-17	17	12	-31	5	14	-3	10	2	-12	-15	-21	-14	-3	-24	8	-2
Sixth Grade																						
Pre (N=4)	91	79	87	75	40	43	53	26	34	38	21	10	28	32	4	11	19	15	7	19	70	0
Post (N=3)	100	90	100	79	58	62	45	8	75	75	68	14	68	10	0	28	40	35	12	40	68	3
Difference: Post-Pre	9	11	13	4	18	19	-8	-18	41	37	47	4	40	-22	-4	17	21	20	5	21	-2	3

Note: Number of students in each group was:

	4th	5th	6th
Pre	13	41	47
Post	26	37	40

[a] N denotes number of classes in group

[b] The pretest classes were not the same as the post-test classes for this trial. The difference score is only a very rough measure.

Table 14

Percent Correct of Total Possible Score on Items in Organizing Lists Quiz - Form B, Trial I by Pre- or Post-Problem Deck and Grade Level

Pre- or Post-Problem Deck	Item 1			Item 2			Item 3							Item 4						
	Answer	Complete	Organized	2a	2b	2c	Answer	List	Complete	Heading	Organized	Structural Error	Executive Error	Answer	List	Complete	Heading	Organized	Structural Error	Executive Error
Fourth Grade																				
Pre (N=1)[a]	54	54	77	92	62	77	46	31	8	19	31	69	0	54	69	23	66	54	15	8
Post (N=2)	58	62	88	96	62	69	38	50	27	6	44	12	19	61	42	35	36	25	4	4
Difference: Post-Pre[b]	4	8	11	4	0	-8	-8	19	19	-13	13	-57	19	7	-27	12	-30	-29	-11	-4
Fifth Grade																				
Pre (N=3)	51	51	82	80	49	76	22	5	2	3	3	46	22	74	70	54	51	42	7	7
Post (N=3)	52	52	74	82	68	47	21	11	8	9	9	32	18	71	74	58	58	53	16	5
Difference: Post-Pre	1	1	-8	2	19	-29	-1	6	6	6	6	-14	-4	-3	4	4	7	9	9	-2
Sixth Grade																				
Pre (N=4)	65	65	93	95	65	77	40	33	16	29	22	26	16	58	58	40	48	39	14	12
Post (N=3)	83	85	96	98	85	85	73	29	24	23	16	29	2	86	100	93	85	58	10	10
Difference: Post-Pre	18	20	3	3	20	8	33	-4	8	-6	-6	3	-14	28	42	53	37	19	-4	-2

Note: Number of students in each group was:

	4th	5th	6th
Pre	13	41	43
Post	26	38	41

[a] N denotes the number of classes used in the analysis.

[b] The pretest classes were not the same as the post-test classes for this trial. The difference score is only a very rough measure.

Table 15

Percent Correct of Total Possible Score on Items in Organizing Lists Quiz - Form A, Trial II for Pre-Post Instruction and Grade Level

Pre- or Post-Test	Item 1				Item 2	Item 3	Item 4							Item 5							
	Answer	Organized	Structural Error	Executive Error			Answer	List	Complete	Heading	Organized	Structural Error	Executive Error	Answer	List	Tree	Complete	Heading	Organized	Structural Error	Executive Error
							Fourth Grade														
Pre (N=4)[a]	48	4	32	16	11	32	39	0	0	0	0	30	11	56	66	0	20	0	5	25	0
Post (N=4)	64	40	61	11	24	46	52	28	22	12	18	26	0	74	89	0	50	0	40	17	0
Difference: Post-Pre	16	36	29	-5	13	14	13	28	22	12	18	-4	-11	18	23	0	30	0	35	-8	0
							Fifth Grade														
Pre (N=3)	66	6	12	21	6	24	39	0	0	0	0	27	0	56	64	0	30	3	6	12	0
Post (N=3)	56	21	38	24	21	38	44	6	3	3	4	18	0	59	79	0	44	0	29	18	0
Difference: Post-Pre	-10	15	26	3	15	14	5	6	3	3	4	-9	0	3	15	0	14	-3	23	6	0
							Sixth Grade														
Pre (N=2)	54	21	21	0	28	28	45	0	0	0	0	38	0	72	86	0	41	3	3	17	0
Post (N=2)	65	35	75	0	38	54	58	21	8	21	21	25	8	94	88	0	71	17	33	0	0
Difference: Post-Pre	11	14	54	0	10	26	13	21	8	21	21	-13	8	22	2	0	30	14	30	-17	0

Note: Number of students in each group was:

	4th	5th	6th
Pre	44	33	29
Post	46	34	24

[a] N denotes number of classes used in the analysis.

Table 16

Percent Correct of Total Possible Score on Items in Organizing Lists Quiz - Form B, Trial II for Pre-Post Instruction and Grade Level

Pre- or Post-Test	Item 1			Item 2	Item 3	Item 4							Item 5						
	Answer	Organized	Structural Error			Answer	List	Complete	Heading	Organized	Structural Error	Executive Error	Answer	List	Complete	Heading	Organized	Structural Error	Executive Error
Fourth Grade																			
Pre (N=4)[b]	40	34	-[a]	19	15	30	4	2	6	0	28	28	31	15	6	11	7	15	13
Post (N=4)	63	77	22	34	48	45	30	14	19	5	30	11	69	84	52	76	34	16	16
Difference: Post-Pre	23	43	--	15	33	15	26	12	13	5	2	-17	38	69	46	65	27	1	3
Fifth Grade																			
Pre (N=3)	36	54	--	21	27	48	0	0	0	0	27	6	36	24	18	6	0	18	3
Post (N=3)	45	68	32	19	13	35	6	3	6	0	19	19	50	52	29	48	27	16	10
Difference: Post-Pre	9	14	--	-2	-14	-13	6	3	6	0	-8	13	14	28	11	42	27	-2	7
Sixth Grade																			
Pre (N=2)	60	63	--	10	17	63	7	7	7	3	23	0	49	13	13	3	3	3	0
Post (N=2)	89	100	3	63	48	74	26	15	26	13	15	11	92	93	78	91	44	7	7
Difference: Post-Pre	29	37	--	53	31	11	19	8	19	10	-8	11	43	80	65	88	41	4	7

Note: Number of students in each group was:

	4th	5th	6th
Pre	47	33	30
Post	44	31	27

[a] Structural errors were not coded for the pretests.

[b] N denotes number of classes in group.

correct. One reason for the students' missing this item was that they were misinterpreting the item and included a "c" in the license plates. The lower grades were less organized in completing their lists. Overall, most sixth- and two-thirds of the fourth- and fifth-grade students achieved this objective.

Objective 3: Evaluate if a list is complete (2BI). Over 80 percent of the students correctly identified when a list was complete. The students were less able to recognize when a list was incomplete. Overall, more than 85 percent of the sixth-grade students correctly evaluated each list. At least one-third of the fourth- and fifth-grade students incorrectly evaluated the lists that were incomplete.

Objective 4: Generate a rule and provide the list (2AI, 1AII). Students in Trial II scored lower and were not as organized on this item as were students in Trial I at the same grade level. A large number of structural errors were made in both trials where too many coins of each denomination were used. The problem was made a little more difficult in Trial II by increasing the number of coins available. Overall, students listed fewer than two-thirds of the correct entries in the list. A large number of structural errors occurred with an increase of these errors between the pretest and post-test in Trial II.

Objective 5: Use a list to solve a problem when told to use a list (3AI, 4BI, 4AII, 5BII). Scores on these items did increase from pretest to post-test in Trial II. More students found the correct answers and more used a list. Items 3AI and 4AII for which one entry from the list is the solution were more difficult than items 4BI and 5BII where the whole list is the solution. Less than a third of the students used lists on the "entry" problem, item 4AII.

Objective 6: Solve a problem that can be solved by using a list (4AI, 3BI, 4BII). Students had small gain scores and a small percentage; 30 percent or less of them used a list on item 4BII. In comparing item 4BII with item 4AII (both items are "entry" problems) it should be noted that in item 4AII students were told to use a list, but in item 4BII no mention of a list was made. The percentage of students who used a list while working these problems was about the same, 30 percent or less at each grade level. A slightly higher percentage of students used a list on item 3BI (same as 4BII), but still most of the percentages were around 30 percent or lower.

Objective 7: Exhaust all possibilities and find all answers (2AII, 2BII). Sixth-grade students did better on these items than did the lower grade students. Less than 40 percent of the students, with the exception of sixth-graders on item 2BII, answered these items correctly. Small gains, from pretest to post-test, were made on items except by fifth-graders on item 2BII.

Objective 8: Find the answer to an "entry" type problem (3AII, 3BII). In general, students scored higher on these items on the pretest and on the post-test than on items 2AII and 2BII (whole list type). Nearly 50 percent of the fourth- and sixth-grade students answered items 3AII and 3BII correctly.

Objective 9: Find all possibilities when a tree diagram is applicable (5AII). Students did better on this item than most of the other items. Over 80 percent of the students used a list while working on the problem. No one used a tree diagram. Over two-thirds of the possibilities in the problem were found by the students.

iv. Summary. There were strong gains from pretest to posttest in Trial II. The only exceptions are with certain items for fifth-grade students. Most of the students at all grade levels could obtain enough information from a list to answer questions about the data. A smaller percentage of the students, around 60 percent, could extend a list given the rule and a few entries. The percentage of students who solved a problem where a list was appropriate or used a list to solve a problem varied according to grade level and problem type.

The differences due to grade level that were observed include:

- Sixth-grade students were more proficient at all of the listing skills (organization, completeness, headings) than other students.
- Sixth-graders used headings on most of their lists. Fourth-grade students used fewer headings than the sixth-graders.
- A greater percentage of sixth-grade students found the correct answers than students in the other two grades. Fourth-grade students scored consistently higher than the fifth-grade students in Trial II. Table 18 shows that the fifth-grade classes in this trial scored lower on the Stanford Achievement Test, Applications part (used in summative evaluation), given in October, 1975 than did the fourth-grade classes.

Differences that were observed in relation to problem types are:

- On "whole-list" problems, a large percentage of students who used a list also used headings. A smaller percentage of the lists were organized (see data on item 5BII, Table 14).
- Larger gains, on the average, were made on correct answers to "whole-list" problems than on "entry" problems in Trial II.

V. Quiz results and problem deck usage. Tables 17 and 18 list for each teacher, the mean total scores on the quizzes, the approximate total time spent by the class on the problem deck, and the mean number of problems tried by the students in each class. Also given is the average converted raw score on the Applications part of the Stanford Achievement Test for each class.

It does not appear that a strong relationship exists between the mean scores on the quizzes and the time spent on the problem deck. There does appear to be some relation between the SAT scores, the quiz scores, and the mean number of problems tried by students in Trial II. The three lowest classes on the SAT had negative or very low gain scores on the quizzes. These classes also averaged the lowest number of problems tried by the students. Teacher 03's class had the highest gain scores in Trial II, a moderate SAT score, and tied with teacher 15's class for the largest mean number of problems tried. Teacher 15's class scored very high on the pretest and essentially had no change on the post-test. Teacher 03 had her class check their own work and for the last part of the class had one child from each of the small groups do a problem at the board to show the whole class. None of the other teachers used this procedure.

vi. Recommendations.

1. Fourth- and fifth-grade students need more instruction/practice on setting up lists, using headings, and organizing the information.
2. It may be that a minimum number of problems to be tried by students should be suggested in the teacher's notes. There is some relationship between the total number of problems

Table 17

Mean Total Score on Quizzes, Approximate
Total Time Spent on Problem Deck and Mean Number
of Problem Tried in Deck by Teacher
Organizing Lists - Trial I

Teacher	Grade	Mean SAT Converted Raw Score	Mean Total Score		Approximate Total Time on Prob. Deck (Hours)	Mean Number of Problems Tried by Student		
			Pre-Prob. Deck Form A/B	Post-Prob. Deck Form A/B		Blue	White	Green
27	4	50		5.92/5.42[a]	3.0[b]	4	2	1
30	4	50		6.77/5.86	9.67	--[c]	--	--
19	4/5	57	5.85/5.46		3.5[b]	7	2	1
06	4/5	57	7.92/6.58		4.5	--	--	--
04	5	54	6.5/4.08		--	3	3	2
02	5	62		4.75/5.75	--	4	1	0
28	5	54		4.54/4.31	--	--	--	--
08	5	54		6.08/6.69	--	3	2	3
29	5/6	62	6.81/6.50		3.5	8	3	1
21	6	72	6.00/4.67		--	7	3	1
17	6	54	6.89/4.88		--	--	--	--
20	6	90		8.47/7.93	--	--	--	--
24	6	72	6.79/5.54		--	10	4	4
18	6	62	7.15/7.15		--	9	3	2
01	6	80		7.23/7.50	5.75	15	2	1
09	6	66		7.83/7.62	4.0	3	3	4

Note: Total possible on Form A is 10 and on Form B is 9. Each correct answer is counted as 1. Problem 4, Form B has a total possible of 4 correct answers.

[a] 5.92/5.42 represents Mean Score Form A/Mean Score Form B

[b] Plus free time

[c] -- data is missing

Table 18

Mean Total Score on Quizzes and Problem Deck Useage by Teacher
Organizing Lists - Trial II

Teacher	Grade	Mean SAT Converted Raw Score	Mean Total Score: Pre-Instr. Forms A/B	Mean Total Score: Post-Instr. Forms A/B	Mean Total Score: Gain Forms A/B	Approximate Total Time on Prob. Deck (Hours)	Mean Number of Problems Tried by Students: Blue	White	Green
40	3/4	--	1.22/1.17	5.75/2.30	4.53/1.13	5.5	7	2	1
03	4	54	6.38/1.67	11.62/6.38	5.24/4.71	4.5	8	3	0
13	4	54	8.27/3.64	10.92/5.60	2.64/1.96	6.0	8	0	0
23	3/4/5	31	7.64/3.11	6.33/4.60	-1.31/1.49	7.0	2	3	0
15	5	58	11.29/4.13	11.26/4.31	-.03/.18	3.0	6	4	1
11	5	44	3.33/1.70	4.27/2.50	.94/0.80	4.0	4	0	1
22	5	26	6.29/1.73	4.38/2.0	-1.92/0.37	--	4	0	0
26	6	62	8.31/3.21	11.20/7.08	2.89/3.87	3.8	--	--	--
14	6	72	7.75/3.69	9.86/5.93	2.11/2.25	2.0	3	2	0

Note: Total possible score on Form A is 14 and on Form B is 8.

tried in the deck and gain scores. But the data is inconclusive on this point.

3. The module developers should identify a checking procedure or procedures that can be used to check the processes used by students to solve a problem.

4. *Summary and Recommendations*

The design for the formative evaluation of the modules includes three general parts: implementation, organization and content, and effectiveness. The analyses and results of the data collected on the Organizing Lists module are discussed in this chapter. At the end of each section specific comments and recommendations were listed. With respect to implementation, the module seems to be flexible and adaptable to the teaching styles of a variety of teachers. The change from Trial 1 to Trial II which introduced a student booklet into the module seems to have facilitated implementation.

The organization of the module for Trial II seems to be clear to the instructor. For both trials the content was well received by students and teachers,with the exception of some concern over the section on tree diagrams in Trial II.

Students seemed to grow in their ability to solve problems as a result of the module. For both trials teachers reported this growth. In Trial II where pretest to post-test data were collected, there was a general growth from pretest to post-test.

There were some recommendations for possible improvements of the module. These are listed below.

1. In the teacher's edition there should be a discussion of how organizing lists fits into the problem-solving process. Vocabulary that is specific to the module and new to the fourth-, fifth- and sixth-grade students should be brought to the teacher's attention, and there should be some mention of the different ways the booklet and problem deck can be implemented.
2. An opportunity for students to have more practice on problems related to particular lessons should be provided. This could be done either by including practice problems in the lesson or keying problems in the deck to the appropriate lesson so teachers can direct students to the problems where practice is needed. The fourth- and fifth-grade students, in general, need more practice than the sixth-grade students.

3. Changes to the problem deck should include
    - categorizing the problems by types and keying to particular lessons
    - deleting problems where using lists is inappropriate
    - adding problems giving students specific practice on using headings and organizing lists.
4. In discussing the implementation of the problem deck in the teacher's edition, it may be good to suggest that students attempt a minimum number of problems in the deck. This level should be set by the teacher considering the characteristics of the class.
5. Different methods teachers can use to check the work of students on problems in the deck should be given in the teacher's edition. The importance of checking that the students are using lists should be emphasized.

C. USING GUESSES TO SOLVE PROBLEMS

1. *Description of the Module*

The module titled Using Guesses to Solve Problems was involved in two trials during the 1975-76 school year in the Oakland Schools. The first was from November 4 through December 16, 1975 and the second from February 18 through March 31, 1976. This is a report of the evaluation activities and findings of both trials.

a. History of the Module: The MPSP policy and advisory boards recommended that the first instructional module developed by the project be one that would test the feasibility of writing instructional materials to teach problem-solving strategies. The problem-solving strategy called "guess and test" was selected as the first strategy for which an instructional module would be developed.

During the 1974-75 school year a module titled Guess and Test was developed by the MPSP staff at the University of Northern Iowa (UNI). This module was involved in two trials during the 1974-75 school year; one at the Oakland Schools and the other at UNI. The teachers that were involved with the trial at the Oakland Schools met with two members of the MPSP evaluation staff to discuss possible revisions in the module. The notes from this meeting are included in Appendix C. The feedback from the Oakland teachers together with interviews and observations of the experimental classes at UNI provided the basis for the revision of the module.

The revised module was examined by representatives from each of the three project sites at the Wagon Wheel Workshop in September, 1975. At this meeting several suggestions were offered for additional revisions in the module prior to the November-December, 1975, trial.

The MPSP evaluation staff at Indiana and the Oakland Schools center conducted the formative evaluation of the November-December, 1975, trial of the module. A verbal evaluation report was given to UNI and the module was revised for the second trial, February-March, 1976. The evaluation of the second trial was also conducted by the MPSP evaluation staff at Indiana and the Oakland Schools center.

b. Description of the Module: At the time of this report, there are three drafts of the module related to the problem-solving strategy called "guess and test." The titles of each of the drafts in the order in which they were developed are: (1) Guess and Test, (2) Introducing Estimation, and (3) Using Guesses to Solve Problems. The first draft was used in the two trials during the 1974-75 school year while the others were used respectively during the first and second trials of the 1975-76 school year.*

For the first draft, the following were the objectives of the module. After completing the module, the students will:

1. be willing to make guesses,
2. be able to organize information,
3. be able to use information to help them make a better guess, and
4. use guessing and testing to solve a problem.

The instructional booklet contained five lessons. The first four lessons were related to one of the four objectives and the fifth lesson was to provide practice solving problems before going to the problem deck. The problem deck contained 108 problems grouped into five levels of difficulty.

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* The module titled Using Guesses to Solve Problems was revised as the result of this evaluation report.

As a result of the feedback from the 1974-75 trials of the first draft and the additional feedback from the project staff at the Wagon Wheel Workshop, several changes were made in the module. First, the objectives and content of the instructional booklet were changed so that they were related to a "type of problem" rather than to "affect and process." The objectives of the booklet were then:

1. Given a problem in which the student must compute until a specified result is obtained, the student will solve the problem. Computations are limited to multiplication basic facts, whole number addends with sums to 100, and subtractions with minuends to 100. No division is required nor expected. (Computation)
2. Given a problem in which the action could be translated into equations of the form $x + y = a$ and $x - y = b$,
   $x + y = a$ and $xy = b$,
   $ax + by = c$ and $dx + ey = f$,
   $ax + b = c$, or $ax - b = c$,
   the student will solve the problem. Solutions are whole numbers less than 10. Parameters (a, b, c, d, e, f) are whole numbers, usually less than 20. (Multiple conditions)
3. Given a problem in which a diagram is the solution, in which a diagram is used to conceptualize (understand) the problem or in which a diagram is used in the solution process, the student will solve the problem. (Diagram)
4. Given a problem in which a student is to estimate a measure or count, the student will make an estimate which most teachers would agree is reasonable. (Measurement)

The first four lessons in the booklet were related to one of these objectives while the fifth lesson was to provide practice solving problems before going to the problem deck. The titles of the lessons were:

1. Using Guessing and Computation
2. Using Guessing in Two-Step Problems
3. Using Estimation with Diagrams
4. Using Estimation in Measurement
5. Applying Estimation in Problem Solving

Similar to the first draft of the module, the problem deck is color-coded to indicate the five levels of problem difficulty. Each card in the deck, in addition to being color-coded to indicate difficulty level, is coded with a letter to indicate the type of problem. Below are the letter codes and an example of each problem type.

C - "computation"

I wrote five different counting numbers on five cards. The sum of the numbers is 15. What numbers did I put on the cards?

M - "measurement"

1. Guess the height of the door.
   - (a) 5 ft.
   - (b) 6 ft.
   - (c) 7 ft.
   - (d) 10 ft.

   The doorknob is 3 feet from the floor. Now can you improve your estimate?
2. Guess the width of the door.

D - "diagram"

A building has 6 stories, each the same height. It takes 10 seconds for the freight elevator to get from the ground floor to the third floor. How long does it take for the elevator to go from the ground floor to the sixth floor - 20 seconds, 25 seconds, 30 seconds?

Table 1

Total Number of Problems of Each Type at Each Level of Difficulty

Difficulty Level	Type of Problem				Total
	M	C	D	V	
blue (easiest)	9	4	6	4	23
yellow	8	9	6	8	31
white	8	10	8	5	31
red	9	9	8	6	32
green (hardest)	7	7	5	5	24
Total	41	39	33	28	141

V - "two-step problems (involving variables)"

On air flight 297 there is one empty seat for every 5 seats filled. The difference between the number of seats filled and the number of empty seats is 64. How many passengers are there on the plane?

Table 1 shows the number of problems of each type at each level of difficulty.

The module developers gave two recommendations in the teacher's booklet with respect to implementing the instructional booklet:

- students should work in fairly homogeneous teams of four;
- one class period be spent on each lesson.

The third draft of the module used in the February-March, 1976, trial was very similar to the second draft. The same problem deck was used for both trials. Below are the objectives and titles of each lesson. Except for minor changes, the lessons and objectives are the same as those in the second draft.

Lesson 1 - Using Guesses and Computation to Solve Problems

Purpose: Given a problem, the student will use guesses and computation to solve it.

Lesson 2 - Using Guesses to Solve Two-Step Problems

Purpose: Given a problem involving two conditions, two variables, or two operations, the student will use guesses to solve it.

Lesson 3 - Using Guesses and Diagrams to Solve Problems

Purpose: Given a problem, the student will use guessing and diagramming to solve it.

Lesson 4 - Using Estimation to Solve Measurement Problems

Purpose: Given a problem and some information, the student will use the information to estimate a solution.

Lesson 5 - Using Guesses to Solve Problems

Purpose: Given a problem of the type encountered in the first four lessons, the student will use guesses or estimates to solve it.

The same recommendations (i.e., homogeneous teams of four and one class period per lesson) were offered for implementing the instructional booklet. For each of the first four lessons the recommended "teaching procedures" were:

1. Direct the activities for the first few pages of each lesson.
2. Allow the students to work at their own pace for the next few pages.
3. Give "optional problems" to early finishers.

A final note is necessary with respect to the objectives of each draft of the instructional booklet. In order to narrow the focus of each lesson, the objectives and content of the second and third drafts were organized around the types of problems in which one might use the "guess and test" strategy rather than around the types of processes one might use in the guess and test strategy (e.g., using information). Although the objectives were changed from the first to second drafts, the "affective and process" objectives of the first draft were not disregarded in the second and third versions of the module. The affective and process objectives were to be included within each of the "problem type" objectives. Figure 1 shows the matrix provided by the module developers to demonstrate the relationship between the two sets of objectives.

Lesson Number/Problem Type Objectives	Affective and Process Objectives		
	Willingness	Organizing Information	Using Information
1. Computation			
2. Two-Step Problems			
3. Diagrams			
4. Measurement			
5. Solving Problems	Practice Solving Problems		

Figure 1

The Relationship Between the Affective and Process Objectives and the Problem Type Objectives

2. *Evaluation Design*

a. Review of General Design: The evaluation of the module was conducted under the general design of the formative evaluation given in Chapter A of this report. Data was collected related to the three major questions of the formative evaluations:

1. What implementation strategies are appropriate for the instructional modules?
2. Is the organization and content of the module appropriate for the intended population?
3. How effective is the module?

All instruments used to collect data for each trial and the number of classes in which the instrument was used are shown in Table 2.

Table 2

Number of Classes in Which Each Evaluation Instrument Was Used

Instrument	Number of Classes Trial I N=9	 Trial II N=9[a]
Time record - instructional booklet	9	7
Time record - problem deck	7	8
Lesson rating form	7	7
Interview questionnaire	6	7
Teacher debriefing questionnaire	8	8
Teacher's booklet (with comments)	9	0
Teacher's problem deck (with comments)	4	0
Student quiz	8	5[c]
Student records - problem deck	5	5
Student work (sample)	0	0
Classroom observations	0	0
In-service tape recordings	1[b]	3
Instructional module (with comments)	4	0

[a] One teacher had a student teacher implement the module and did not provide any feedback.

[b] For the first two in-service sessions notes were recorded rather than tape recording. A tape recording was collected for the third in-service session.

[c] Pretests and post-tests were administered for Trial II.

For both trials classroom observations were not performed due to scheduling difficulties. The evaluation staff decided to collect samples of student work after the second trial had begun. For Trial II, the teacher's comments regarding the booklet and problem deck were provided during the in-service sessions rather than written in the module. Written comments from the project staff were not requested for the second trial.

b. Quizzes - Trial I: For the first trial of the module, six forms of a quiz were developed (see Appendix C). Each form contains 13 items. The first 12 items were developed to measure one of the objectives of the module (computation problems, multiple-condition problems, measurement problems, and diagram problems). A multiple-choice format was used for these 12 items. The last item on every form is a problem for which the student is asked to try and write as much as possible about how he/she worked the problem. Table 3 shows which items are related to which objective on the six forms of the module quiz.

The answers for the first 12 items were scored as either correct or incorrect. For problems number 13, all except the item on form 4B are "multiple-condition problems." These items were scored as either (1) correct, (2) incorrect, because one condition was not maintained or, (3) incorrect. Item 13, form 4B, is not a multiple-condition problem and was scored as either correct or incorrect.

Quizzes - Trial II: The module quiz was revised based on an item analysis with the quizzes used in Trial I. Four forms of a quiz were developed using a selection of items from the first trial (see Appendix C). The format of each form of the quiz used in Trial II is exactly the same as the format of each form of the quiz used in Trial I. Table 4 shows

Table 3

Quiz Items by Module Objectives - Trial I

Objective	Form 4A	4B	5A	5B	6A	6B	Total[a]
Computation	1,2,3	1,2,3	1,2,4	1,2,4	1,2,4	1,2,4	17[b]
Multiple Conditions	4,5,6	4,5,6	3,5,6	3,5,6	3,5,6	3,5,6	18
Diagrams	7,8,9	7,8,11	7,8,9	7,8,9	7,8,9	7,8,9	18
Measurement	10,11,12	9,10,12	10,11,12	10,11,12	10,11,12	10,11,12	18
Solve a Problem[c]	13	13	13	13	13	13	6

[a] This number is the total number of problems that were used as a measure of each objective.

[b] One problem (#1, 5A) was deleted from the analysis as a result of a typing error.

[c] These items are not related specifically to one objective.

Table 4

Quiz Items by Module Objectives - Trial II

Objective	Form C[a]	4	5	6	Total[b]
Computation	1,2,4	1,2,3	1,2,4	1,2,4	12
Multiple Conditions	3,5,6	4,5,6	3,5,6	3,5,6	12
Diagrams	7,8,12	7,8,12	7,8,12	7,8,12	12
Measurement	9,10,11	9,10,11	9,10,11	9,10,11	12
Solve a Problem[c]	13	13	13	13	4

[a] The C represents a "common" form of the quiz that one-half of the students at each grade level were administered.

[b] This number is the total number of problems that were used as a measure of each objective.

[c] These items are not related specifically to one objective.

which items are related to which objective on the four forms of the module quiz. Also, every item on the quiz for Trial II was scored as either correct or incorrect.

c. Data Collection: The data collection procedures for both trials were the same as those described in the general formative evaluation design (see Chapter A). For Trial I, the quiz was administered as a post-test while for Trial II the quiz was administered as a pretest and post-test. Also, control students were administered the post-test for Trial I.

3. *Analysis and Results*

a. An Analysis of Implementation: The formative evaluation attempted to answer four questions with respect to the implementation of the module:

i. How do the teachers implement the instructional booklet and problem deck?

ii. How much time do the teachers spend on the instructional booklet and the problem deck?

iii. How many problems at each level of difficulty were selected?

iv. What recommendations do the teachers have for implementing the modules in the curriculum?

i. Implementation procedures. For Trial I, teachers recorded the procedures they used to implement the instructional booklet and problem deck on the teacher's booklet and time-record - problem deck, respectively. For Trial II, the teachers were interviewed with respect to the implementation procedures they selected. The procedures recommended for implementing the module were essentially the same for both trials.

Although different teachers participated in each trial of the module, the implementation procedures and comments concerning the procedures

Table 5

A Selection of Procedures Used to Implement Module for Trials I and II

Booklet	Problem Deck
- Whole class instruction.	- Small groups; students selected their own groups. - Tended to be heterogeneous. - Students selected their own cards.
- Whole class but provided individual help.	- Worked individually. - Selected their own cards.
- Whole class for the first two pages, then small group work for the remainder of the lesson.	- Groups of four. - Selected their own cards.
- Small groups of four.	- Small groups of four. - Solved problems sequentially.

were for all practical purposes identical for each trial. The feedback from the teachers shows that a variety of procedures were used to implement the instructional booklet and problem deck and that the teachers were generally pleased with the procedures they used. Table 5 shows a selection of the procedures that were used in both trials.

Most of the teachers followed the recommended teaching procedures (e.g., homogeneous teams of four) and were satisfied with that approach. However, there were teachers in both trials who did not follow the recommendations of the module developers but were satisfied with the procedures they used. For example, some teachers used whole-class instruction rather than small groups and found this to work well for their students and their teaching styles. Several teachers used heterogeneous groups and were pleased with that approach, while one teacher used homogeneous groups and suggested that heterogeneous groups may have been better. It appears that the recommended teaching procedure is one method for implementing this module but not the only method. The teacher feedback from both trials indicates that the module can be implemented using procedures that are congruent with a teacher's usual instructional style.

The recommendations of the module developers do not include a statement concerning the procedures to be used for selecting problems from the deck. In Trial I, three of the five teachers who reported the procedures they used indicated that the cards were solved in sequence while two of the teachers allowed their students to select their own cards. For Trial II, nearly all teachers allowed their students to select their own cards. This will be commented on further when considering the question of how many problems at each level of difficulty were selected.

ii. Amount of time. Tables 6 and 7 show the amount of time devoted to the instructional booklet for both trials. Every teacher from Trial I stated that every lesson was too long to complete in one class period. The fifth- and sixth-grade teachers felt "pushed" to complete one lesson per day and the fourth-grade teachers reported it was practically impossible for them to meet this recommended schedule. Tables 6 and 7 also show that the fourth-grade teachers on the average spent a greater number of minutes each class period and a greater number of class periods on each lesson. For Trial I, the greatest amount of time was devoted to lesson four. The section on "organization and content" will attempt to explain why that amount of time was required to complete lesson four.

Some of the comments related to the amount of time needed to complete the instructional booklet from Trial I were:

- We could have used at least 3 or 4 more days.

Table 6

Periods of Time Used for the Instructional Booklet by Teacher for Each Lesson

		Trial I				
		Lesson Number				
Teacher	Grade	1	2	3	4	5
40	3/4	4[a]	4	4	4	4
13	4	5	5	5	4	4
23	3/4/5	5	5	3	4	5
15	5	3	2	4	5	5
11	5	4	2	4	4	2
22	5	2	2	2	3	2
26	5/6	4	3	3	5	4
14	6	2	5	2	2	2
		Trial II (N=7)				
		2.6[b]	2.3	2.7	2.3[c]	2.3[c]

[a] 1. Less than 35 minutes
2. 35-45 minutes
3. 46-55 minutes
4. 56-65 minutes
5. Greater than 65 minutes

[b] These numbers are the mean time for all teachers in Trial II. Data on individual teachers was not recorded.

[c] N = 6 for lessons 4 and 5.

Table 7

Number of Class Periods Used for Each Lesson by Teacher

Trial I							
		Lesson Number					
Teacher	Grade	1	2	3	4	5	Mean
40	3/4	1	1	1	1	1	1.0
13	4	1	2	2	2	1	1.6
23	3/4/5	2	2	1	1	2	1.6
15	5	1	1	1	1	1	1.0
11	5	1	1	1	2	1	1.2
22	5	1	1	1	1	1	1.0
26	5/6	2	2	1	1	1	1.4
14	6	1	2	1	1	1	1.2
Mean		1.2	1.5	1.1	1.3	1.1	1.26

Trial II (N=6)					
Lesson Number					
1	2	3	4	5	Mean
1.0[a]	1.0[b]	1.0	1.0	1.2	1.04

[a] These numbers are the mean time for all teachers in Trial II.

[b] N=7 for lessons 2 and 3

- The booklet was so long it became tiresome.
- Twenty additional student hours were needed.

With regard to the amount of time that was needed to complete the instructional booklet for Trial I, the recommendation was to shorten all of the lessons, with particular attention given to lesson four. The teacher feedback from Trial I related to the "organization and content" of the booklet (see the next section of this report) identified some areas in each lesson which should be changed or removed.

The amount of time spent on the instructional booklet for Trial II was recorded on computer sheets by the teachers. The data for each teacher was not kept and, as a result, data on individual teachers is not reported. The data in Tables 6 and 7 indicates that the amount of time spent on each lesson was closer to the recommended "one lesson per class period" for Trial II than for Trial I. Further evidence that the teachers were generally able to complete one lesson per class period was obtained from the teacher interviews. Also, there is no evidence from Trial II, that the teachers at the different grade levels found difficulty maintaining the recommended schedule. It appears that the amount of content in each lesson of the booklet used for Trial II is generally able to be taught to fourth-, fifth-, and sixth-grade students in one class period averaging between 35 and 45 minutes in length.

Table 8 shows that the total number of minutes devoted to work with the problem deck ranged between 78 and 675 for Trial I and 154 and 960 for Trial II. The section titled "effectiveness" will consider whether the amount of time spent with the problem deck had any effect on student performance.

Table 8

Amount of Time Used for the Problem Deck

Teacher	Grade	Number of Days	Average Number of Minutes per Day	Total Minutes
Trial I				
40	3/4	11	56[a]	611
13	4	9	50	451
03	4	6	13	78
23	3/4/5	15	45	675
11	5	7	30	210
22	5	11	25	270
14	6	4	45	180
Trial II				
27	4	16	60	960
19	4	9	43	387
06	4/5	4	83	332
04	5	9	20	180
21	5/6	7	22	154
20	6	8	45	360

[a] Rounded to the nearest whole minute

Table 9

Total Number of Problems Attempted at Each Level of Difficulty

Trial I

Difficulty Level	Teacher Number 11	13	14	15	22	Total
blue	150	220	129	578	200	1277
yellow	49	--	11	336	129	525
white	64	--	60	202	107	433
red	61	--	17	159	80	317
green	62	--	22	94	37	215
Total	386	220	239	1369	553	12767

Trial II

Difficulty Level	Teacher Number 27	02	04	21[a]	20	Total
blue	119	240	104	33	81	577
yellow	84	126	80	8	84	382
white	47	54	56	1	143	301
red	20	24	45	14	215	318
green	26	0	33	0	65	124
Total	296	444	318	156	588	1702

[a] Half of the student problem deck records were reported by this teacher as lost.

iii. Problem card selection. Five teachers from each trial provided data with respect to the frequency of card selections at each level of difficulty. Table 9 shows that the students in classes 15 and 20 attempted the most problems during Trials I and II respectively. For all teachers, except teacher 20, the frequency of problems attempted generally decreased as the level of difficulty increased. The section on "effectiveness" will consider whether these patterns in card selections are reflected in the students' performance on the module quiz.

It was previously mentioned that three of the five teachers in Trial I had their students solve problems sequentially from the deck, while most of the teachers in Trial II allowed their students to select their own cards in any order. Even though these two different methods were used for selecting cards, the same pattern can generally be observed for all teachers; that is, as the level of difficulty increases the frequency of card selections decreases.

iv. Comments and recommendations.

1. The instructional booklet and problem deck were implemented in a variety of ways. Most of the teachers felt that the ability grouping procedures they selected and the amount of time spent on each lesson were appropriate for their students. The recommended teaching procedures (i.e., homogeneous teams of four and one class period per lesson) appear to be one way to implement the module, but not the only way that can be successful. The teacher's edition should mention that a variety of ways have been tried and have been found to be successful. Several of the ways that have been used to implement the booklet and problem deck could perhaps be described.
2. It appears that the module that was used for Trial II can be taught with one lesson per class period with most fourth-, fifth-, and sixth-grade students.

3. The teacher's booklet does not identify a recommended amount of time that the students should work in the problem deck. Even if there is not a recommended amount of time, some discussion of this point should be included in the teacher's edition.
4. Many of the students in Trial II selected their own problems, while for Trial I, most students selected problems in sequence. Both procedures resulted in a decrease in the frequency of card selections as the level of difficulty of the problems increased. This pattern is what one would expect.

b. Organization and Content: The evaluation data related to the organization and content of the module (both versions) will be grouped and analyzed in an attempt to answer three major questions:

i. What editorial changes (e.g., format) need to be made in the instructional booklet and problem deck?
ii. Are the objectives of the module congruent with the content of the module?
iii. Are there any trends in the problem card selections that suggest changes in the module?

At the end of this section a list of conclusions/recommendations will be given that synthesize the findings related to these questions.

The three questions given above are concerned with the major questions of the evaluations. The formative evaluations attempted to answer a greater variety of questions related to the organization and content of the two drafts of the module. The following instruments/forms in Appendix A should be examined to identify the range of questions examined in the evaluations:

- Interview questionnaire,
- Teacher debriefing questionnaire,
- In-service discussion questions,
- Lesson rating form.

i. Editorial changes. The teachers provided a great deal of written feedback in the teacher's booklet for the first trial and verbal feedback during the in-service sessions for both trials related to the organization and content of the modules. Evaluation data was obtained for both trials from the "Teacher Debriefing Questionnaire" and the "Lesson Rating Form." Also, the teachers in both trials were interviewed individually approximately one month after Trial II.

Most of the questions on the "Teacher Debriefing Questionnaire" received at least 75% affirmative responses, indicating general teacher satisfaction with the module. Table 10 shows the items on the "Teacher Debriefing Questionnaire" for which greater than 25 percent of the responses were negative related to Trial I. Also shown is the number of reponses to these same items for Trial II. It appears that the concerns of the Trial I teachers related to (1) a crowded format, (2) the clarity of the instructions to the student and (3) the variations in the difficulty of the content, were not identified as weaknesses in the instructional booklet used for Trial II. Although several teachers in Trial II responded "not sure" concerning the (1) appropriateness of the booklet for all ability levels and (2) overemphasis of certain topics, the data from the in-service sessions and teacher interviews do not suggest that appropriateness and overemphasis are problems.

For both trials, the responses to the remaining items on the "Teacher Debriefing Questionnaire" related to the organization and content of the module were practically all positive. It appears that the teachers in both trials were pleased with the:

- sentence structure and vocabulary in the booklet,
- sequence of the lessons,
- relationship of the activities and illustrations to the interests of the students.

Table 10

Responses to Selected Items on the "Teacher Debriefing Questionnaire" for Trial I and Trial II

Item	Number of Yes Responses	Number of No Responses	Not Sure[a]
Does the display format avoid a crowded appearance?	4,7[b]	4,0	0
If a student booklet is used, are the instructions to the learner complete, clear, and easy to follow?	5,7	2,0	0
Have adjustments been made to the instructional material to accommodate learners of different aptitudes?	5,5	3,0	2
Does the product avoid overemphasizing topics which do not merit detailed treatment?	5,3	2,1	3
Does the product avoid extreme variations in the difficulty of the content?	5,6	3,1	0

[a] This response was not included on the "Teacher Debriefing Questionnaire" for the first trial.

[b] These represent the number of responses from Trials I and II, respectively.

Table 11 shows the mean responses on the "Lesson Rating Form" for both trials. For all three questions and for every lesson, the means are higher for Trial II than for Trial I. For the question related to ability level, the responses on the "Lesson Rating Form" support the data from the "Teacher Debriefing Questionnaire" for Trial I; that is, that there was some concern as to whether the content of the booklet was appropriate for low-ability students. For Trial I, the means for lesson four are lower than the means for all of the other lessons concerning their appropriateness for the (1) ability levels of the students and (2) overall purpose of the module.

Table 11

Mean Responses on the "Lesson Rating Form" for Both Trial I and Trial II[a]

Trial	Lesson 1	2	3	4	5	Mean
How appropriate is the lesson for the ability level of your students?						
1[b]	4.08	3.58	3.67	3.25	4.06	3.73
2	4.29	4.00	4.29	4.33	4.50	4.28
How appropriate is the lesson for the overall purpose of the module?						
1	4.17	4.25	4.25	3.53	4.22	4.08
2	4.43	4.43	4.43	4.50	4.67	4.49
How useful were the teacher's notes for each lesson?						
1	3.32	3.42	3.42	3.33	3.43	3.38
2	4.71	5.0	4.71	4.83	4.83	4.82

[a] A five point scale was used where 1 was "inappropriate" and 5 was "appropriate."

[b] N=9 for Trial I; N=7 for Trial II.

The teacher's notes in the booklet used for Trial II include:

- the title and purpose of the lesson,
- an overview of the lesson,
- a recommended teaching procedure,
- authors' comments.

The notes in the booklet used for Trial I provided only a discussion of the purpose of the lesson. The data in Table 11 indicates that the format used for Trial II was rated quite appropriate.

Appendix C contains all of the editorial feedback from the teachers included in the teacher's booklet and/or discussed during in-service sessions and teacher interviews. For Trial I, the following comments for each lesson are examples of the feedback that was provided.*

Lesson 1:

- Kids could understand this...
- Kids were excited.
- Confusing format at some places
- Easy, even for slow students

Lesson 2:

- The level of difficulty is not consistent within the lesson.
- Crowded appearance
- Worked well

Lesson 3:

- Fun for all students...a chance for slower students to do well
- Some of the diagrams are confusing.

Lesson 4:

- Very confusing
- Students did not like the lesson at all.
- Students were frustrated.

Lesson 5:

- Worked well
- Students were not frustrated as with previous lesson (number four).

General Comments:

- The lessons are too long.
- Some pages were easy; others were very difficult.

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* Some of the comments represent summaries of several teachers' (at least three) comments.

The comments above from Trial I suggest a general acceptance of and enthusiasm for the module. They do support evidence of some concerns presented earlier in this paper related to at least four topics. First, the lessons were felt to be generally too long to complete in one period. The section on implementation also shows that nearly every lesson required more than one class period to complete. The "crowded format" of the booklet was identified in the data from the "Teacher Debriefing Questionnaire" as well as frequently noted in the written and verbal editorial comments. Third, the fluctuations in the difficulty of the content were identified as a weakness in the module from the data on the "Lesson Rating Form" and from the written and verbal comments. Finally, the "Lesson Rating Form" and the editorial feedback both show that lesson four was rated the lowest by the teachers for Trial I; the editorial feedback indicated specific weaknesses in the lesson.

A verbal report of the concerns from Trial I was given to the staff at UNI prior to the revision of the module for Trial II. A copy of all of the teachers' editorial comments was also sent to UNI.

The teachers' comments concerning the revised booklet used for Trial II included only editorial suggestions. The specific editorial comments from Trial II may be found in Appendix C. One change that appeared in the revised booklet used in Trial II was the inclusion of several problems at the end of each lesson for "early finishers." The teachers found these problems to be very useful and successful. Several teachers did recommend that more problems be included, especially ones for high-ability students. It appears that the revision of the booklet eliminated most of the concerns raised in Trial I.

ii. Objectives of the module. The problem-solving strategy titled "Guess and Test" is a process that consists of at least the following steps:

1. Make a guess.
2. Check the guess.
3. Use the first guess to make a better guess.
4. Repeat 1-3.

This strategy was selected by MPSP as the first one to use for testing the feasibility of developing instructional materials to teach problem-solving strategies. The process given above is not described in the teachers' booklet. In an attempt to determine whether this process was evident in the module, the Trial II teachers were asked during individual interviews (1) what they perceived to be the objective of the module and (2) if the materials were congruent with that objective.

Most of the teachers identified the objective of the module to be a process similar to the one given above. These same teachers also felt that the process was present in the instructional booklet. However, they did feel it was necessary to identify that process for the students and continually reinforce its use throughout the experiences with the problem deck.

iii. Problem card selections. Tables 12, 13, and 14 were developed for the purpose of identifying trends in the problem card selections. The following observations seem most salient with respect to the selections.

Table 12

1. The multiple-condition problems (V) were attempted least in both trials among the four problem types.

2. The green multiple-condition problems (V) were attempted least in both trials among the four problem types at each level of difficulty.
3. The diagram (D) and measurement (M) problems were attempted most frequently in both trials. The measurement problems in Trial I were attempted a much greater number of times than the other problem types. This is interesting since the measurement lesson was the least popular one according to teacher reports.

Table 13

4. For both trials the percent of the total number of problems attempted for each problem type is very close to the percent of the total problems available in the deck of that type.
5. Nearly half of the problems attempted during Trial I are at the blue (easiest) level of difficulty.

Table 14

6. For Trial I, as the level of difficulty increases, the percent of the problems rated hard increases. For Trial II, the white problems were rated the most difficult. When the results for both trials are combined, the green problems were rated the hardest followed by the white cards, not the red ones as one would expect.
7. The Trial I students rated a higher percentage of the problems "hard," than did the Trial II students. This observation in Table 14 is supported by the verbal feedback from the teachers that the problems in the deck seemed difficult for the students. The teachers in Trial II did not mention that the problems in the deck appeared to be too difficult for the students. The numbers of teachers at each grade level were very similar for both trials.
8. The percentages of problems rated as "liked" for each problem type are nearly the same.

The data in this section related to the organization and content of the module was grouped into three categories: (1) editorial changes, (2) objectives of the module, and (3) problem card selections. The data analysis in this section suggests the following recommendations/ comments related to the organization and content of the module (specifically, the one used for the second trial).

Instructional Booklet

1. A discussion concerning the role of "Guess and Test" in problem solving should be included in the teacher's booklet or premodule activities.
2. The "overview" of each lesson should relate the objective of that lesson to the overall objective, i.e., the "Guess and Test" strategy.
3. It appears that the teachers that used this module were able to identify for the most part the "Guess and Test" process in the booklet. Those same teachers mentioned that they found it necessary to continually review that process while the students were solving the problems in the deck. Since all the teachers did not identify this process, a detailed discussion of the "Guess and Test" strategy should be included. This recommendation is closely related to number one.
4. Nearly all of the teachers were satisfied with the content and format of the booklet.
5. The teacher's notes were quite appropriate for the teachers in Trial II.

Problem Deck

6. The alphameric code on the problem cards should be explained in the teacher's booklet.

Table 12

Total Number of Problems Attempted by Students at Each Level of Difficulty and Problem Type

Trial I (N=5 classes)

Difficulty Level	Problem Type C	D	M	V	Total
blue	229(4)[a]	367(6)	473(9)	208(4)	1277(23)
yellow	114(9)	84(6)	180(8)	147(8)	525(3
white	132(10)	110(8)	127(8)	64(5)	433(31)
red	92(9)	63(8)	98(9)	64(6)	317(32)
green	66(7)	42(5)	71(7)	36(5)	215(24)
Total	633(41)	666(38)	949(33)	519(28)	2767(133)
Trial II (N=5 classes)[b]					
blue	97(4)	218(6)	204(9)	58(4)	577(23)
yellow	79(9)	107(6)	106(8)	90(8)	382(31)
white	133(10)	49(8)	73(8)	46(5)	301(31)
red	68(9)	82(8)	79(9)	89(6)	318(32)
green	25(7)	59(5)	28(7)	12(5)	124(24)
Total	402(41)	515(39)	490(33)	295(28)	1702(133)

[a] Total number of problems available at each level.

[b] Half of all the data for one class in Trial II was lost for that Trial.

Table 13

Percent of Total Number of Problems Attempted for Each Difficulty Level and Problem Type

Difficulty Level	Problem Type				Total
	C	D	M	V	
Trial I					
blue	8(2)[a]	13(5)	17(7)	8(3)	46(17)
yellow	4(7)	3(5)	7(6)	5(6)	19(24)
white	5(8)	4(6)	5(6)	2(4)	16(24)
red	3(7)	2(6)	4(7)	2(5)	11(25)
green	2(5)	2(4)	3(5)	1(4)	8(18)
Total	22(29)	24(26)	36(31)	18(22)	100(108)[b]
Trial II					
blue	6(2)	13(5)	12(7)	3(3)	34(17)
yellow	5(7)	6(5)	6(6)	5(6)	22(24)
white	8(8)	3(6)	4(6)	3(8)	18(24)
red	4(7)	5(6)	5(7)	5(5)	19(25)
green	1(5)	3(4)	2(5)	1(4)	7(18)
Total	24(29)	30(26)	29(31)	17(22)	100(108)

[a] Percent of total problems available at each level.

[b] Greater than 100 due to rounding error.

Table 14

Percent of Problems Rated as Hard and Disliked at Each Level of Difficulty and Problem Type

Difficulty Level	Problem Type				Total
	C	D	M	V	
Trial I					
blue	10,14[a]	13,14	6,22	10,15	9,13
yellow	11,10	7,6	8,7	5,12	8,9
white	12,14	11,12	16,13	11,17	13,14
red	22,13	13,10	19,9	27,5	20,9
green	48,23	24,24	39,21	42,22	38,23
Total	21,15	14,13	18,14	19,14	18,14
Trial II					
blue	5,7	4,5	2,3	5,3	4,4
yellow	12,10	13,17	1,1	21,17	11,11
white	14,11	11,9	15,13	20,13	22,11
red	12,8	4,7	4,8	13,10	9,8
green	14,9	24,12	0,8	17,0	18,10
Total	11,9	9,9	4,5	15,10	11,8
Total					
blue	8,11	9,10	4,13	8,9	7,9
yellow	12,10	10,12	5,4	13,15	10,10
white	13,13	11,11	16,15	16,15	23,13
red	17,11	9,9	12,9	15,8	15,9
green	31,16	24,18	20,15	30,11	28,17
Total	16,12	12,12	11,10	17,12	15,11

[a] The first number indicates the percent of students that indicated that problems in these categories were "hard", and the second number that they were "difficult". The percent rated "easy" and "liked" can be found by subtracting each of the numbers respectively from 100.

7. For each problem type, the percentages of problems rated as "liked" are nearly the same.
8. The specific difficulty ratings for the white problems should be considered. Overall, these problems were rated more difficult than the red problems.

c. Effectiveness:

i. Teacher judgment. This section of the report will be primarily concerned with the data from the module quizzes related to student performance. Student performance was assessed directly through module quizzes and indirectly through collective teacher judgment. During the in-service sessions and/or individual interviews the teachers were asked what they believed to be the most successful attributes of the module. The following comments are a selection of those received from Trials I and II.

Trial I

- It made students think about what they are reading and analyze their thoughts.
- The enthusiasm and willingness of the students to tackle problems.
- It made the students think.
- It gave the students a willingness to guess.
- Problem card format.

Trial II

- It made the kids think differently and realize there is frequently more than one solution to a problem.
- Format of the materials, that is, a booklet followed by a problem deck.
- Attitudinal gains.
- Interesting problems.
- Students of all ability levels found success with the module.

Clearly, most of the comments above are related to dimensions of effectiveness other than student performance. Some of the dimensions reflected in the above comments are (1) attitudes, (2) format of the materials, and (3) the appropriateness of the module for all ability levels.* It appears that the module may have had a positive effect on many different areas.

ii. Module quizzes. The module quizzes used for the evaluations were developed by the MPSP evaluation staff at Indiana with the assistance of one of the module developers from the University of Northern Iowa (UNI). For Trial I, six forms of a quiz were administered as a post-test only to 212 students that participated in the trial (experimental group) and 74 students that did not participate (control group). For Trial II, four forms of a quiz were administered as a pretest - post-test to 225 students. "Control" students were not used for Trial II.

Four separate analyses of the quiz results are included in this section. The quiz results were analyzed by objective and grade level:

(1) for both trials combined,

(2) across trials,

(3) for each trial separately,

(4) with respect to the problem card selections.

A specific criterion level for successful performance was not established. Rather, the quiz results were examined for any trends that suggested changes in the module.

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* In the section on organization and content, it was mentioned that the Trial I teachers found the content of the module too difficult for low-ability students. In contrast, three teachers in Trial II (two fourth and one sixth) commented that the material was appropriate for all ability levels.

In each of the four analyses the fifth-grade classes generally scored lower than the fourth- and sixth-grade classes. Although this trend is present in the classes involved in both trials, it is most obvious in Trial I (see Tables 17, 18, and 19). In an attempt to identify a cause for this trend, the scores on the Stanford Achievement Test (SAT) for each class were analyzed.* Table 15 shows that the mean scores for:

(1) the fourth- and fifth-grade classes are quite close for both trials while the sixth-grades scores are the highest.

(2) Trial I, the mean SAT score for the fourth-graders (teachers 40, 13, & 23) is 43.5 and 43.7 for the fifth-graders.

(3) Trial II, the mean SAT score for the fourth-graders is 50.0 and 58.0 for the fifth-graders.

(4) Trial I, the mean SAT score for the seven teachers is 49.6 and, for Trial II, 65.6.

Table 15

Mean Adjusted SAT Scores for the Classes Used in the Analyses of the Quizzes

Trial I			Trial II		
Teacher Number	Grade	Mean Adjusted SAT	Teacher Number	Grade	Mean Adjusted SAT
40	3/4	--[a]	27	4	50
13	4	54			
23	3/4/5	31			
15	5	58	02	5	62
11	5	44	04	5	54
22	5	26			
26	6	62	21	6	72
14	6	72	20	6	90

[a] Missing data.

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* The SAT was administered at the beginning of the school year as one of the summative evaluation instruments of MPSP.

These four observations are reflected for the most part in the quiz results for the two trials. With regard to the first observation, the sixth grade performed the highest in Trial II but scored lower than the fourth-graders in Trial I (see Table 17). For observations two and three, Table 17 shows that the fifth-graders in Trial I scored lower than the fourth-graders by 15.2 percentage points* while the difference for Trial II is only 4.5 percentage points, and the fourth-grade means for both trials are nearly the same (50.5 for Trial I versus 54.9 for Trial II). Tables 17, 18, and 19 support the fourth observation in that the means for the Trial II classes are generally higher than the means from Trial I.

This analysis concerning the observed trend in the performance of the fifth-grade students does not directly contribute to suggestions for revising this module. However, the analysis does show that for these teachers the mean SAT scores for each grade appear to be reflected in the performance on the module quiz. Since one purpose for developing the module quiz was to construct an evaluative instrument to accompany the final version of the module, further analysis of a possible interaction between the SAT scores and the scores on the module quiz would contribute to establishing the validity of the module quiz. The activities required to carry out this recommendation were not performed by the MPSP evaluation staff due to the termination of the project.

For both trials combined, Table 16 shows that the mean percent of correct solutions on all forms of the module quiz for both trials is 51.0 percent.

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* The fourth- and fifth-grade students were administered different tests for Trial I.

The highest performance was on the first objective related to "computation" (71.6%) and the lowest performance was on the last problem on the quiz (30.0%). On all except one form of the quiz the last problem is a multiple-condition problem. However, the type of multiple-condition problem that was selected for the last problems is similar to only eight of the 28 multiple-condition problems in the deck. Also, these eight problems were attempted a total of 250 times which is only six percent of the total attempts. On the other hand, the items used for objective two, multiple conditions, are similar to the majority of multiple-condition problems in the deck. These problems make up 27 percent of the total number of problems attempted. The performance related to objective two was somewhat higher (47.8%) than the performance on the last problems (30.0%).

Table 16

Quiz Results by Objective and Grade Level for Both Trials Combined

Objective	Grade 4 (N=171)	 5 (N=136)	 6 (N=126)	Mean
Computation	75.6	67.0	72.3	71.6
Multiple Conditions	50.6	38.1	54.7	47.8
Diagrams	48.9	40.8	56.0	48.6
Measurement	54.2	53.5	62.8	56.8
Solve a Problem Using Guess and Test	36.8	27.5	25.8	30.0
Mean	53.2	45.3	54.3	51.0

Since the problems used for the last items on the quizzes are also, for the most part, multiple-condition problems, Table 16 shows that performance on all of the "multiple conditions" items was the lowest. The section of this report on organization and content (see Table 13) shows that the multiple-condition problems were attempted the least number of times in both trials. The data in Table 16, together with the frequency of card selections, suggests that the number of cards attempted is reflected in the performance on the quiz. This point will be discussed later in this section.

Across Trials. Table 17 shows that the performance of the Trial II students on the module quiz was higher than that of the Trial I students for:

- each grade level collapsed across objectives,
- each objective collapsed across grade level, and
- thirteen of the fifteen means at each grade level and objective.

Although many reasons may account for these trends, four possible reasons are: (1) the ability levels of the students, (2) the difficulty of the quizzes, (3) the effectiveness of the revised module, and (4) the different teachers. An analysis of the mean SAT scores for the classes in both trials shows that the mean for Trial II (65.6) is higher than the mean for Trial I (49.6) (see Table 15). The quizzes used in Trial II were developed by analyzing those used for Trial I. Therefore, it is doubtful that the difficulty level was any less for the forms used in Trial II. With regard to reasons three and four, it is clearly not possible to determine the exact contributions of these factors. In the light of teachers' comments discussed earlier, it seems reasonable to attribute some of the improvement in scores to the changes in the module.

For each trial separately. Tables 18 and 19 show the quiz results for each trial. For the most part, the trends observed in these tables are the same as those in Tables 16 and 17. The data in Tables 18 and 19 is best interpreted with respect to the problem card selections.

Table 17

Percent of Correct Answers on Quizzes Across Trials and By Grade Level and Objective

	Grade							
	4		5		6		Combined	
Objective	I[a] (N=93)	II (N=78)	I (N=65)	II (N=71)	I (N=54)	II (N=76)	I (N=212)	II (N=225)
C[b]	73.1	78.3	56.3	72.3	66.1	75.5	65.2	75.4
V	51.3	50.3	37.5	38.4	42.0	61.0	43.6	49.9
D	43.4	51.7	30.1	46.2	38.9	64.5	37.5	54.1
M	58.1	52.3	48.2	56.1	52.4	68.0	52.9	58.8
S	26.8	41.8	4.6	39.0	22.2	27.7	17.8	36.2
Mean	50.5	54.9	35.3	50.4	44.3	59.3	43.4	54.9

[a] I - Trial One; II - Trial Two

[b] C - Computation
V - Multiple Conditions
D - Diagram
M - Measurement
S - Solve a problem using guess and test

Problem card selections and quiz results. Table 18 shows the quiz results for Trial I at each grade level and objective. The following observations can be noted from Table 18:

(1) The fifth-grade means are less than the fourth- and sixth-grade means for every objective.

(2) For all but one objective at the fourth grade, the fourth- and sixth-grade experimental means are greater than the control means.

(3) The mean for all grades is the lowest with respect to the problems where the student must attempt to find a solution and show his/her work.

(4) The mean score for all grades and objectives is 43.4.

Observations 1, 3, and 4 are consistent with the trends previously discussed when the results for both trials were combined. Observation two

Table 18

Quiz Results by Objective and Grade Level for Trial I

	Grade			
Objective	4 (N=93 Exp.) (N=13 Con.)	5 (N=65 Exp.) (N=48 Con.)	6 (N=54 Exp.) (N=13 Con.)	Total Mean (N=212 Exp.) (N=74 Con.)
C	73.1(74.6)[a]	56.3(63.4)	66.1(59.5)	65.2(65.8)
V	51.3(46.0)	37.5(34.7)	42.0(37.3)	43.6(39.3)
D	43.4(35.3)	30.1(34.3)	38.9(35.7)	37.5(36.2)
M	58.1(53.2)	48.2(47.4)	52.4(35.5)	52.9(45.4)
S	26.8[b](8.4)	4.6(18.2)	22.2(15.5)	17.9(14.0)
	43.5(--)[c]	34.2(30.7)	46.3(44.1)	41.3(37.9)
	50.4(70.2)	59.8(49.0)	31.5(40.5)	47.2(53.2)
Mean	50.5(43.5)[d]	35.3(39.6)	44.3(36.7)	43.4(39.9)

[a] The number in parentheses indicates the mean percent of correct solutions for the control students.

[b] The first number is the mean percent of correct answers, the second is the mean percent of responses that maintained some of the conditions, and the third is the mean percent of responses that did not maintain any of the conditions in the problem.

[c] This item was not a multiple-condition problem.

[d] The mean percent of correct responses on the last item was used to calculate this mean.

is interesting. Even though the mean performance for the fourth and sixth-graders is less than 50 percent, the experimental students performed better than the control students.

Table 19 shows the quiz results at each grade level and objective for Trial II plus the mean gain in percent from the pretest to post-test. The following observations seem most relevant from this table.

(1) There were gains from pretest to post-test for each grade and each objective with the exception of the 5th grade with objective C.

(2) The fifth-grade means are less than the fourth- and sixth-grade means for most of the objectives.

(3) The mean percent of correct answers for solving problems using guess and test is lowest for grades four and six and next to the lowest in grade five.

(4) For grades four and six, the greatest gain was for the "diagram" problems.

(5) For grade five, the greatest gain was on the item where they had to solve the problem(s).

(6) The least gain was for the multiple condition items at grades four and five and for the correct solution to the "solve a problem..." items at grade six.

(7) The highest mean at each grade level is for the "computation" items.

(8) The mean performance for all grades and forms of the quiz ranges from 48.9 to 59.3 percent.

The data in Table 20 suggests that for Trial I, there is not a strong relationship between the average total number of problems attempted by each student and performance on the quiz, nor between the total amount of time spent with the deck and performance on the quiz.* Also, a strong relationship does not appear to exist between the average number of problems attempted by each student at each level of difficulty and performance on the quiz.

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* A rank-order correlation coefficient was used to suggest trends in the data.

Table 19

Percent of Correct Answers by
Grade, Form, and Objective

Fourth Grade

Objective	Form 4(N=38)		Form C(N=40)		Mean[a]	
	Post-Test	Gain	Post-Test	Gain	Post-Test	Gain
C	83.3[b]	13.3	73.3	8.8	78.3	11.1
V	45.6	1.4	55.0	6.6	50.3	4.0
D	49.1	20.1	54.2	17.2	43.4	31.8
M	58.8	12.9	45.8	3.3	58.1	8.1
S	21.1	8.6	62.5	11.9	26.8	10.3
Mean	51.6	11.3	58.2	9.6	51.4	13.1

Fifth Grade

Objective	Form 5(N=35)		Form C(N=40)		Mean	
	Post-Test	Gain	Post-Test	Gain	Post-Test	Gain
C	77.1	2.8	67.5	-6.5	72.3	-3.7
V	34.3	6.7	42.5	-4.7	38.4	1.0
D	39.0	23.8	53.3	11.7	46.2	17.8
M	51.4	4.8	60.8	9.9	56.1	7.4
S	42.9	34.3	35.0	25.4	39.0	31.9
Mean	48.9	14.5	51.8	8.0	50.4	10.9

Sixth Grade

Objective	Form 6(N=38)		Form C(N=38)		Mean	
	Post-Test	Gain	Post-Test	Gain	Post-Test	Gain
C	73.7	7.0	77.2	8.8	75.5	7.9
V	63.2	10.5	58.8	6.6	61.0	8.6
D	58.8	19.3	70.2	17.2	64.5	18.3
M	72.8	8.8	63.2	3.3	68.0	6.1
S	0.0	-5.3	55.3	11.9	27.7	3.3
Mean	53.7	8.1	64.9	9.6	59.3	8.8

[a] Forms C and 4 combined

[b] Mean percent of correct solutions

Table 20

Problem Deck Use and the Quiz Results

Trial I

Class/ Teacher Number	Grade	Difficulty Level					Total	Total No. of Minutes Spent with Problem Deck	Class Mean on the Post-Test, Gain[a]
		B	Y	W	R	G			
13	4	9[b]	-	-	-	-	9	450	53.4
11	5	6	2	3	2	2	15	210	32.8
15	5	18	11	6	5	3	44	--[c]	47.1
22	5	13	8	7	5	2	35	275	26.9
14	6	4	0	2	1	1	8	180	42.3
Mean		10	5	5	3	2	25	279	40.5
					Trial II				
27	4	4	3	2	1	1	11	60	65.1,31.7
02	5	9	5	2	1	0	17	120	57.1,3.
04	5	4	2	3	2	1	12	180	51.3,9.
21	5/6	-[ac]	-	-	-	-	--	---	-----
20	6	3	3	5	7	2	20	360	79.0,13.
Mean		5	3	3	3	1	15	180	63.0,14.4

[a] A post-test only was used for Trial I.

[b] Average number of problems attempted by each student rounded to the nearest whole number.

[c] Missing data.

For Trial II, the data in Table 20 suggests some relationship between the performance on the quiz and (a) the average total number of problems attempted and (b) the average number of problems attempted at each level of difficulty. Also, some relationship appears to exist between the gain scores and the average number of problems attempted by each student at each level of difficulty.

iii. Summary of student performance on the module quiz. In this section the data from the module quiz for both trials of the module was analyzed. Also, a summary and discussion of the teachers' comments related to the effectiveness of the module was presented. The results of the data analyzed in this section are summarized below and followed by recommendations related to possible revisions in the module.

1. The teacher feedback from both trials suggests that the module may have had a positive effect on many different areas (see p. 98).
2. In Trial I the experimental students outperformed the control students across objectives. In Trial II there were consistent pretest - post-test gains across objectives (with the exception of the fifth grade on objective C).
3. The fifth-grade mean scores in both trials generally are less than the means for the fourth and sixth grades. Some evidence was presented to suggest a possible interaction between scores on the Stanford Achievement Test and scores on the module quiz. For example, the fifth-grade students' SAT scores were generally lower than the SAT scores for the fourth- and sixth-grade students.
4. The mean percent of correct solutions on all trials was 51.0. The students in Trial II scored higher than the students in Trial I at nearly every objective and grade level. Four possible explanations were presented for the higher scores in Trial II (see p. 103).
5. The items in which the student must perform a computation to solve the problem (i.e., C-type problems) have the highest mean scores for all grades and objectives.

6. The last problem on each quiz is one in which the student is asked to solve the problem and write his/her work on the quiz paper (compared to multiple choice for the remaining quiz items). Except for the fifth-grade students in Trial II, the mean scores on these problems were lower than all other mean scores.
7. In Trial II, the greatest gain score for the fourth and sixth grades is related to the "diagram" items.
8. Some relationship appears to exist for the classes in Trial II between the quiz performance and the average total number of problems attempted overall and at each level of difficulty. Also, some relationship was noted between the gain scores for the Trial II classes and the average number of problems attempted by each student at each level of difficulty.

iv. Recommendations. While the module appears to be generally effective and well received, there remain some considerations which bear further investigation.

1. Further analysis of a possible relationship between the SAT scores and the scores on the module quiz should be performed.
2. The higher performance of the experimental students compared to the control students in Trial I suggests that the students were better able to solve the items on the quiz as a result of experiencing the module, yet the mean score of correct answers for the experimental classes was only approximately 50 percent. The relatively low performance by all students can perhaps be attributed to (1) the difficulty of the module quiz and/or (2) the difficulty of the module.

3. The experiences with using diagrams to solve problems appear to have improved the students' ability to solve problems using diagrams. The large gain scores related to the "diagram" items in Trial II suggest that some consideration should be given to determining if there are any features of the lesson on diagrams which could be used to enhance other lessons.
4. Since some relationship was found between the average number of problems attempted at each level of difficulty and a class's gain scores on the module quiz, consideration should be given to a minimum number of problems that should be attempted at each level of difficulty.*

4. *Summary and Recommendations*

The module titled Using Guesses to Solve Problems was involved in two field tests during the 1975-76 school year in the Oakland Public Schools, Oakland County, Michigan. The first was from November 4 through December 16, 1975, and the second from February 18 through March 31, 1976. The formative evaluations of both trials were conducted under the general design of the formative evaluation given in Chapter A. Data was collected concerning the three major questions of the formative evaluations related to the implementation, organization and content, and effectiveness of the module. This section will summarize the results of the evaluation findings for both field tests related to each of the major questions.

a. Implementation:

1. The instructional booklet and problem deck were implemented in a variety of ways. Most of the teachers felt that the ability-grouping

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* A discussion of this issue is included in the revised teacher's module developed as a result of this report.

procedures they selected and the amount of time spent on each lesson were appropriate for their students. The recommended teaching procedures (i.e., homogeneous teams of four and one class period per lesson) appear to be one way to implement the module but not the only way that can be successful. The teacher's booklet should mention that a variety of ways have been tried and have been found to be successful. Several of the ways that have been used to implement the booklet and problem deck could perhaps be described.

2. It appears that the module that was used for Trial II can be taught with one lesson per class period with most fourth-, fifth-, and sixth-grade students.
3. The teacher's booklet does not identify a recommended amount of time that the students should work in the problem deck. Even if there is not a recommended amount of time, some discussion of this point should be included in the teacher's booklet.*
4. Many of the students in Trial I solved problems sequentially in the deck, while most of the students in Trial II selected their own problems. Both procedures resulted in a decrease in the frequency of cards selected as the level of difficulty of the problems increased. This trend was expected.

b. Organization and Content:

1. A discussion concerning the role of "guess and test" in problem solving should be included in the teacher's booklet or premodule activities.*
2. The "overview" of each lesson should relate the objective of that lesson to the overall objective, i.e., the "guess and test" strategy.

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* This issue is discussed in the revised teacher's booklet prepared as a result of this report.

3. It appears that the teachers that used this module are able to identify for the most part the "guess and test" process in the booklet. Those same teachers mentioned that they found it necessary to continually review that process while the students were solving the problems in the deck. Since all the teachers did not identify this process, a detailed discussion of the "guess and test" strategy should be included. This recommendation is closely related to number one.
4. Nearly all of the teachers were satisfied with the format of the booklet. Specific editorial recommendations are included in Appendix C.
5. The teacher's notes were quite appropriate for the teachers in Trial II.
6. The alphameric code on the problem cards should be explained in the teacher's booklet.*
7. Some consideration should be given to a recommendation that a minimum number of problems be solved in the deck and/or at each level of difficulty, in order to establish the likelihood of a minimum level of mastery. However, it is important to keep in mind that the problem deck was developed so that students at all ability levels could find some success with the problem deck; and, as a result, it may be unreasonable to identify some number of problems that should be attempted at each level of difficulty by all students.
8. For each problem type, the percentages of problems rated as "liked" are nearly the same.

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* A discussion of the alphameric code is included in the revised teacher's module prepared as a result of this report.

9. The specific difficulty ratings for the white problems should be considered. Overall, these problems were rated more difficult than the red problems. However, most of the white problems were attempted by fifth-grade students, not sixth-grade students. The white problems may be most appropriate for sixth-grade students; and if so, this could be a reason why the white problems were rated more difficult than the red problems.

c. Effectiveness: The section related to the "effectiveness" of this module was primarily concerned with the students' performance on the module quiz. However, it was acknowledged that student performance is only one dimension of an effective instructional product. Many of the other dimensions of an effective instructional product are implicitly and explicitly identified in statements one through nine above. An analysis of the data included in the sections titled "implementation" and "organization and content" and the data related to the students' performance suggests that the module had a positive effect on students in several areas. Many of the summary comments and recommendations that are related to the effectiveness of the module have already been stated with reference to the implementation and organization and content. In addition, the following comments are related to the effectiveness of the module.

1. Further analysis of a possible interaction between the SAT scores and the scores on the module quiz should be performed.
2. The higher performance of the experimental students compared to the control students in Trial I suggests that the students were better able to solve the items on the quiz as a result of experiencing the module, yet the mean score of correct answers for the experimental classes was only approximately

50 percent. The relatively low performance by all students can perhaps be attributed to (1) the difficulty of the module quiz and/or (2) the difficulty of the module.

3. The experiences with using diagrams to solve problems appear to have improved the students' ability to solve problems using diagrams. The large gain scores related to the "diagram" items in Trial II suggest that some consideration should be given to determining if there are any features of the lesson on diagrams which could be used to enhance other lessons.
4. Since some relationship was found between the average number of problems attempted at each level of difficulty and a class's gain scores on the module quiz, consideration should be given to recommending that a minimum number of problems be attempted at each level of difficulty. However, it is important to keep in mind that the problem deck was developed so that students of all ability levels could find some success with the problem deck; and, as a result, it may be unreasonable to identify some number of problems that should be attempted at each level of difficulty by all students.

D. USING TABLES TO SOLVE PROBLEMS

1. *Description of the Module*

The module titled Using Tables to Solve Problems was involved in one trial during the 1975-76 school year in the Oakland Schools (February 18 through March 31, 1976). This is a report of the evaluation activities and findings of that trial.

The purpose of this module is to provide a sequence of experiences to introduce students to the use of tables in problem solving. The instructional booklet contains six lessons and the problem deck contains five levels of problem difficulty. The six lesson titles and the objectives of each lesson are:

1. Making a Table

   Objective: Given a physical situation involving a numerical relationship, the students will place entries in a table that describes the numerical relationship.

2. Completing a Table

   Objective: Given some entries in tables, the students will determine the relationship and complete the table.

3. Using Tables to Solve Problems

   Objective: Given problem situations, the student will make tables to solve a series of related problems.

4. Using Tables to Solve More Problems

   Objective: Given mathematical problems, the students will build tables and determine entries to solve the problems.

5. Reading Tables

   Objective: Given a completed table, the student will be able to read the table to answer a list of questions.

6. Solving Problems

Objective: To acquaint students with the problem deck.

It is important to note that the purpose of this module is to introduce students to the use of tables in problem solving. This module was developed as part one of a two-module sequence on using tables to solve problems. Part two of the sequence has not been developed. As a result, the objectives of this module do not include all the objectives one might identify as relevant for using tables to solve problems.

Each card in the problem deck, in addition to being color-coded to indicate difficulty level, was coded with a letter to indicate the type of problem. Below are the letter codes and an example of each problem type.

C - "complete the table"

1BC1

Hint: Each tricycle has 3 wheels.

COMPLETE THE TABLE.

Number of tricycles	5		20		
Number of wheels		30		24	300

S - "answer a sequence of questions"

5BS1

Hint: Every time you turn the handle 3 turns, the bait goes down 5 feet.

Turns of Reel	3						
Feet	5						

1. The fish locator shows fish at 15 feet. How many turns of the handle should I make to lower the bait 15 feet?
2. About how deep are you fishing when it takes 12 turns of the handle to raise the bait to the surface?

M - "make a table"

6BM1

MAKE A TABLE WITH 5 MORE ENTRIES TO SHOW THE NUMBERS OF WHEELS NEEDED.

Wagons	1	2					
Wheels	4	8					

Hint: Each wagon has 4 wheels.

B - "answer the bottom line question"

29BB1

A cartoon commercial runs at 24 frames per second. An artist has to draw a cartoon for each frame.

Seconds	1	2			
Frames	24	48			

How many cartoon drawings does an artist have to make for a 15-second commercial?

Hint: For 10 seconds you would need 240 drawings.

R - "read the table"

27BR1

AIRLINE MILEAGE CHART

	Chicago	Denver	Los Angeles	New York	San Francisco	Washington, D.C.
Chicago	X	901	1746	719	1847	617
Los Angeles	1746	849	X	2454	340	2286
New York	719	1617	2454	X	2566	200

How far is it between these cities:

1. Chicago to Denver?
2. Los Angeles to New York?
3. New York to Washington, D.C.?

Hint: Find the row for Chicago. Then read the number under Denver. That number is the distance in miles from Chicago to Denver.

Table 1 shows the number of cards of each type at each level of difficulty.

Table 1

Total Number of Problems of Each Type at Each Level of Difficulty

	Type of Problem					
	C	S	M	B	R	Total
Blue (Easiest)	9	8	10	2	4	33
Yellow	10	6	9	3	6	34
White	6	12	1	6	12	37
Red	4	4	5	10	6	29
Green (Hardest)	6	6	3	5	3	23
Total	35	36	28	26	31	156

For each of the first five lessons the recommended "teaching procedure" was:

1. Discuss the opening scene (given in the booklet).
2. Guide the students as a whole class through two or three pages of the lesson.
3. Observe and listen to the students as they work in independent small groups on several pages of the module.

4. Give "optional problems" to groups who finish early. For lesson six, the teachers were to prepare the students to enter the problem deck by having them solve problems. In addition to these recommendations, the module developers suggested:

- one class period be spent on each lesson, and
- small groups of four students is the "best" way to organize the class for presenting the module.

2. *Evaluation Design*

a. General Design: The evaluation of the module was conducted under the general design of the formative evaluation given in Chapter A of this report. Data was collected related to the three major questions of the formative evaluations:

1. What implementation strategies are appropriate for the instructional modules?
2. Is the organization and content of the module appropriate for the intended population?
3. How effective is the module?

All instruments used to collect data and the number of classes in which the instrument was used are shown in Table 2.

Teacher comments concerning the booklet and problem deck were discussed as a group at the in-service session rather than written in the module. The evaluation staff did not decide to collect samples of student work for the formative evaluations until after the date the teachers had begun working with this module. Due to time constraints, classroom observations and written comments from the project staff were not collected. Also, the quiz was not available until the end of instruction.

b. Quiz: Two forms of a quiz were developed for the evaluation (see Appendix D). The objectives to be measured by the quiz were:

Table 2

Number of Classes from Which Data Was Obtained for Each Instrument

Instrument	Number of Classes (N = 8)
Time record-instructional booklet	8
Time record-problem deck	4
Lesson rating form	8
Interview questionnaire	6
Teacher debriefing questionnaire	8
Teachers booklet (with comments)	0
Teachers problem deck (with comments)	0
Student quiz	7
Student records-problem deck	3
Student work (sample)	0
Classroom observations	0
In-service tape recordings	1[a]
Instructional module (with comments)	0

[a] This number refers to one tape recording, not the number of classes.

1. Given a table, the students will be able to read the table.
2. Given a table with two categories and the entries in the first column, the student will be able to generate other entries in the table.
3. Given a table with three categories and a random selection of the entries missing, the student will be able to complete the table.
4. Given a problem and told to use a table to solve the problem, the student will correctly a) write the headings for the table, b) complete some entries in the table, and c) solve the problem.

5. Given a problem in which a table could be used to obtain the solution but was not suggested to the student, the student will a) use a table to solve the problem, and b) correctly solve the problem. If a table is used, the student should enter acceptable headings for the table.

The objectives to be measured by the quiz were developed by the evaluation staff at Indiana, not by the module developers. The objectives of the quiz were, for the most part, congruent with the objectives of the module; however, one exception needs to be noted. Objective 3 was not an objective of the module, but since the problem deck contains several three-category tables, this objective was included as one to be measured on the module quiz.

The items written to measure each objective on each form are:

Items - Form A	Objective	Items - Form B
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5

For problem 1, all four parts on form A and three out of four parts on form B are multiple-choice items. The fourth part of number 1, form B, is a completion item. The remaining problems on both forms are ones where the student is required to complete or generate a table. Table 3 shows the criteria and corresponding points that were assigned to the items for the purpose of scoring the quiz.

Table 3

Criteria and Points for Each Item of the Tables Module Quiz

Item	Criteria	Points
1	Correct answer	1
	Incorrect answer	0
2	All entries are correct	2
	Some entries are correct	1
	No entries are correct	0
3	All entries are correct	2
	Some entries are correct	1
	No entries are correct	0
4	Correct headings	1
	Incorrect headings	0
	All entries correct	2
	Some entries correct	1
	No entries correct	0
	Correct answer	1
	Incorrect answer	0
5	Correct answer	1
	Incorrect answer	0
	Used a table to solve	1
	Did not use a table to solve	0
	There is evidence the student tried to use a table	1
	No evidence of a table	0
	Correct headings	1
	Incorrect headings	0
	No structural error	1
	Structural error (An error in understanding the problem)	0
	No executive error	1
	Executive error (An error in manipulation or calculation)	0

All of the teachers except one gave the quiz to their students after at least three weeks of work with the problem deck. One teacher was ill for an extended period of time and administered the quiz to his students when they had had no work in the problem deck. This will be commented on further in the analysis section of this report. Each teacher randomly distributed the two forms of the quiz to his/her students so that one half completed form A and the other half form B.

c. Data Collection: The first teacher in-service session for this module involved all of the activities described in the "general evaluation design" of the formative evaluations. The data collection outline for the formative evaluations involved three additional in-service sessions for the primary purpose of evaluating the modules. Due to ice storms, the first and second evaluation in-service sessions for this module were cancelled. As a result, the feedback on the booklet and problem deck was obtained during the third session.

It is important to note that the group of teachers (group 11) that field tested this module consisted of only fifth- and sixth-grade teachers and students. No data is available to determine the appropriateness of this module for fourth-grade students.

3. *Analysis and Results*

a. Implementation: The formative evaluation attempted to answer four questions with respect to the implementation of the module:

1. How do the teachers implement the instructional booklet and problem deck?
2. How much time do the teachers spend on the instructional booklet and the problem deck?
3. How many problems at each level of difficulty were selected?

4. What recommendations do the teachers have for implementing the modules in the curriculum?

i. Description of Implementation Procedures. Table 4 shows the implementation procedures used by six of the teachers. In an effort to examine how well the module "fit in" with the teacher's usual instructional mode the teachers were asked to describe their usual instructional mode in mathematics and other areas and compare their usual procedures to their work with the module. It is interesting that many of the teachers changed instructional modes when they began working with the module (e.g., individualized to whole class) and that none of the teachers felt any difficulty with the change. It appears that a variety of ways were used to implement the booklet and all the teachers were pleased with the approach they selected. A variety of ways were also used to implement the problem deck. Most of the teachers did use some form of small-group instruction and homogeneous grouping seems to have worked best. It is also important to note that in most of the classes the students selected their own cards, rather than the teacher assigning the cards.

The format of this module (an instructional booklet followed by a problem deck) is one of several that could be used to teach problem solving strategies and skills. Another format would be to provide the students with carefully selected problems and simply have the students solve a lot of problems. Since the research on problem solving is not conclusive concerning efficacious instructional formats, the teachers were asked whether the instructional booklet was necessary or whether some form of practice with the problem deck would have been sufficient for teaching the students to use tables in problem solving. The teachers' responses to this issue are part of the statements listed under "transition from booklet to deck" in Table 4. The other statements under this heading refer to the issue of

Table 4

Implementation Procedures for the Booklet and Problem Deck

Teacher number/ grade	Usual instructional mode	Booklet	Deck	Transition from booklet to the deck	Comments
08/5	-Math-homogeneous groups of 6-10 -Whole class in other areas	-Whole class	-Students selected teams(2-4) -Usually homogeneous	-Good	-Problem deck is the heart of the module -The mode he used was felt to be the best considering all the ones he tried last year
28/5	-Math-completely individualized -All modes in other areas	-Whole class	-Heterogeneous groups(3-5) -Teacher assigned groups -Selected own cards	-Good -Booklet is needed and first -He needed to review the booklet at times	-He would use homogeneous groups the next time
29/5-6	-Math-completely individualized -All modes in other areas	-Whole class	-Students selected -Tended to be homogeneous -Group membership changed -Selected own cards	-Good -Booklet is needed and first -She needed to review the booklet at times	-Worked well for these students
05/5-6	-Small groups and individualized in all areas	-Whole class for the 1st page, then individual work	-Student selected groups of 2 -Selected own cards	-Good	-None

Table 4 (cont.)

Implementation Procedures for the Booklet and Problem Deck

Teacher number/ grade	Usual instructional mode	Booklet	Deck	Transition from booklet to the deck	Comments
18/6	-Heterogeneous groups in all areas	-Individual work	-Homogeneous groups of -Teacher selected one member of the group to explain the solution -Students moved at their own rate	-Good -Booklet is a good introduction	-Worked well
24/6	-Individualized in all areas	-Whole class for the first 3 lessons -Some went individually, most remained with the whole class	-Individuals & small groups -Selected own mode	-Booklet made students "willing" to try problems	-None

how well the instructional booklet prepared the student to enter the problem deck. The responses from the teachers indicate that (1) the booklet is needed for instruction in grades 5 and 6 and (2) the booklet adequately prepares the students to enter the problem deck.

ii. Amount of Time. Tables 5 and 6 show the amount of time each teacher spent with the instructional booklet. Almost every lesson was taught in one class session with the mean length of a session around 45 minutes. Although teacher 05 took nearly two class sessions for each lesson, the mean number of minutes he spent on each lesson was less than the mean for all teachers. The fifth- and fifth/sixth-grade teachers spent approximately the same number of class sessions on each lesson as the sixth-grade teachers but required a greater number of minutes to complete a lesson. This data agrees with the reports of the fifth- and fifth/sixth-grade teachers that they were "pushed" to complete some of the lessons in one class period of "usual" length. Lessons 2 and 3 required the greatest number of class periods and minutes to complete for all of the teachers. Another observation from Tables 5 and 6 is that the number of class periods used for each lesson and the length of each period remained rather constant for each teacher. Other than the two observations that (1) lessons 2 and 3 required the greatest amount of time and (2) fifth-grade teachers had to spend more minutes on each lesson than sixth-grade teachers, the fluctuations in the amount of time spent on the booklet seem to be a function of the individual teacher's style. The data in Tables 5 and 6, together with the teachers' comments, suggests that:

1) most of the lessons can be taught in one class period at grades 5 and 6;
2) the lessons require on the average 45-50 minutes to complete at grades 5 and 6; and
3) lessons 2 and 3 should perhaps be shortened.

Four teachers recorded the amount of time spent on the problem deck. Table 7 shows the reports of these teachers. When the teachers were interviewed concerning the instructional patterns they selected, each teacher was satisfied that his/her approach was successful in his/her classroom. These four teachers each spent around three weeks with the problem deck. Although several teachers commented that they could have used more time to solve problems in the deck, they felt that three weeks

Table 5

Number of Class Sessions for Each Lesson

Teacher Number	Grade	Lesson 1	2	3	4	5	6	Mean
08	5	1	1	1	1	1	1	1.0
28	5	1	1.5	2	1	1	1	1.3
29	5/6	1	1	1	1	1	-	1.0
05	5/6	2	2	2	2	1	1	1.8
01	6	1	1	1	1	1	1	1.0
09	6	1	1	2	1	1	1	1.2
18	6	1	1	1	1	1	1	1.0
24	6	1	1	1	1	-	1	1.0
	Mean	1.1	1.2	1.4	1.1	1.0	1.0	1.12

Table 6

Number of Minutes Spent on Each Lesson

Teacher Number	Grade	Lesson 1	2	3	4	5	6
08	5	2[a]	4	2	2	2	4
28	5	4	3	5	4	4	2
29	5/6	3	4	4	4	4	-[b]
05	5/6	2	4	4	2	2	1
01	6	2	2	2	2	2	2
09	6	4	4	4	2	1	-
18	6	-	4	3	4	4	1
24	6	1	1	1	1	1	-

[a] 1 - less than 35 min.
2 - 35-45 min.
3 - 45-55 min.
4 - 55-65 min.
5 - greater than 65 min.

[b] Data was not reported for the empty cells.

was an adequate amount of practice prior to taking the quiz. The data from Table 7 and teacher interviews indicate that the problem deck was implemented using a variety of instructional patterns and the teachers were pleased with the approaches they selected.

Table 7

The Instructional Patterns/Time That Four Teachers Spent With the Problem Deck

Teacher Number	Instructional Pattern/Time
08	The deck was available for 18 days... students worked on cards during "free time."
24	The students used the cards twice a week for three weeks.
28	The deck was used for five consecutive complete periods and two more periods on successive Fridays.
29	The deck was used for four weeks, two or three times per week, for one-half hour each time.

iii. Problem Card Selection. Only three teachers provided a record of the problems their students selected. Table 8 shows that the frequency of cards selected generally decreased as the difficulty increased. This observation is interesting since the students in nearly every class selected their own cards. Class 29 attempted a great many more problems than the other two classes. The section on "effectiveness" will examine whether the number of problems attempted by class 29 compared to the other two classes is reflected in the performance on the module quiz.

Table 8

Total Number of Problems Attempted at Each Level of Difficulty for Three Teachers

Difficulty Level	Teacher Number			
	08	28	29	Total
Blue	157	102	309	568
Yellow	89	171	100	360
White	81	33	78	192
Red	45	66	61	172
Green	43	7	32	82
Total	415	379	580	1374

iv. Comments and Recommendations. The data discussed in this section suggests several recommendations related to the implementation of the module:

1. The instructional booklet and the problem deck were implemented in a variety of ways. Every teacher felt that his/her methods were appropriate for his/her students. The recommended teaching procedures given in the teacher's booklet (see pp. 119-120) appear to be one method for using the module. The teacher's booklet might list several other methods that have been used to implement the module.

2. It appears that the booklet can be used in six days (one day per lesson) with most fifth- and sixth-grade students: Lessons 2 and 3 should be shortened. The problem deck was used for approximately three weeks prior to administering the module. All classes, however, did not spend the same amount of time with the problem deck during the three weeks. Although the teachers stated they could have used more time with the deck, they felt that their procedures for implementing the problem deck during the three weeks were adequate preparation for the quiz. The teacher's booklet does not identify a recommended amount of time for the students to work in the deck. Even if there is not a recommended amount of time, some discussion of this point should be included in the teacher's booklet.

3. Most of the students were allowed to select their own cards from the deck. Three teachers reported the card selections with 580, 415, and 379 problems attempted in these classes. The section titled "effectiveness" will consider whether the number of cards attempted is related to the performance in these three classes.

b. Organization and Content: The formative evaluation attempted to answer a variety of questions related to the organization and content of the module. The following instruments/forms in Appendix D should be examined to identify the questions considered in the evaluation:

- Interview questionnaire
- Teacher debriefing questionnaire
- Action research discussion questions
- Lesson rating form

Appendix D contains a summary of the data obtained from the interviews and discussion sessions. This data, together with the results of the Teacher Debriefing Questionnaire and Lesson Rating Form, indicates that nearly every teacher involved in the field testing of this module was pleased with:

1. the congruency between the objectives and the content of the module,
2. the display and format of the booklet and problem deck, and
3. the mathematical, psychological, and pedagogical appropriateness of the module's content for the grade and ability levels of the students.

Both strengths and weaknesses of the module can be identified from the data. The teachers reported that the major weaknesses of the module were:

1. The module lacks variety in that:
   a. most of the problems are "constant ratios," and
   b. there are very few problems of the type where the students are given the problem statement, asked to solve the problem using a table but not given the headings and some of the entries.
2. The booklet does not emphasize for the teacher and student the variety of ways that one can generate the entries in the tables.
3. The module does not explain the difference/relationship between using tables versus using organized lists to solve problems.*

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* Prior to using the "tables" modules, these teachers field-tested the Organizing Lists module. The teachers felt that if both modules are to be used by a teacher, a discussion of the difference/relationship between the two modules would be useful.

The first weakness must be examined related to the purpose of this module. The purpose is to introduce students to the use of tables in problem solving and not to provide all of the experiences related to this skill. Since the teachers were unaware of the "introductory" purpose of the module, this first concern of the teachers is not of major importance. It does imply, however, that this module alone cannot be presented to teachers as one that contains all of the skills related to using tables to solve problems.

At the first teacher session the project staff provided a detailed explanation of the module's content. Included in that explanation was a discussion of the variety of ways that can be used to generate the entries in the tables used in the module. During the individual teacher interviews, nearly every teacher commented that they would not have seen the different ways to generate entries if it had not been for the in-service sessions. Moreover, every teacher stated that the teacher's notes were not useful in this respect. This was further evident from the responses on the Lesson Rating Form. The teachers also felt that the module attempted to "show" the students how to generate entries through the use of true-false items but more emphasis was needed. Two of the fifth-grade teachers and the teachers who had some fifth-grade students in their classes felt that fifth-graders had greater difficulty generating entries than sixth-graders. This will be commented on further in the "effectiveness" section of this report.

Group 11 field tested the module titled Organizing Lists three months before using this module. Although all of the teachers felt there were differences and similarities between the types of problems in the two modules, none was able to identify the difference(s)/relationship.

Since the developers feel that the heart of the module is the problem deck, the patterns in problem card selections are of particular interest.

Tables 9, 10, and 11 were developed for this purpose. The following observations seem the most salient with respect to the problem card selections. (Note: The data in these tables is the result of feedback from only three teachers.)

Table 9

Total Number of Problems
Attempted for Each Problem Type at
Each Difficulty Level[a]

Difficulty Level	Problem Type					Total
	C	S	M	B	R	
Blue	239(9)[b]	129(8)	167(10)	5(2)	29(4)	568(33)
Yellow	101(10)	77(6)	108(9)	41(3)	33(6)	360(34)
White	30(6)	64(12)	13(1)	49(6)	36(12)	192(37)
Red	25(4)	15(4)	52(5)	58(10)	22(6)	172(29)
Green	18(6)	16(6)	11(3)	33(5)	4(3)	82(23)
Total	412(35)	301(36)	351(28)	186(26)	124(31)	1374(156)

[a] N = 3

[b] (9) cards of this type and difficulty level are in the deck.

Table 9

1. The "reading" (R-type) problems were tried on the average by the fewest number of students. The quiz results to be discussed in the next section show that around ninety-five percent of the students were able to read tables.

2. The S- and B-type problems were attempted fewer times than the C- and M-type problems. Although the S-, B-, C-, and M-type problems all require the student to complete a table, the S- and B-type problems ask the student a question (B-type) or questions (S-type). Perhaps a question(s)

on the card led the students to select these types of problems less frequently.

Table 10

Percent of Total Number of Problems Attempted
for Each Problem Type and Difficulty Level

Difficulty Level	Problem Type					
	C	S	M	B	R	Total
Blue	17(6)[a]	9(5)	12(6)	<1(1)	2(3)	40.5(21)
Yellow	7(6)	6(4)	8(6)	3(2)	2(4)	26(20
White	2(4)	5(8)	1(1)	4(4)	3(8)	15(25)
Red	2(3)	1(3)	4(2)	4(6)	2(4)	13(19)
Green	1(4)	1(4)	1(1)	2(3)	<1(2)	5.5(15)
Total	29(23)	22(24)	26(16)	13.5(16)	9.5(21)	100(100)

[a] (6) percent of the total number of cards in the deck are of this type at this level of difficulty.

Table 10

3. Twenty-one percent of all cards were R-type problems while only 9.5 percent of all problems attempted were this type. The teacher interviews revealed that these problems were good for motivation but reading tables was not a new skill for the students in these classes.

4. Nearly 30 percent of all the problems selected were type C with 17 percent of the 30 from the blue difficulty level. Nine blue cards were C-type with seven of the nine located in the first third of the blue problems. Although most students selected their own cards, the data on the individual problems indicates that the students selected most of the problems from the first third in each difficulty level. The large percentage of C-type (and blue-C-type) problems selected may be due to the location of the cards in the deck rather than to some other character-

istic of the problems.

Table 11

Percent of Students that Rated Problems as
Hard and Disliked at Each Level of
Difficulty and Problem Type for Three Teachers

Difficulty Level	Problem Type					
	C	S	M	B	R	Total
Blue	9,13[a]	8,12	2, 6	0,20	7,11	7,11
Yellow	29,23	18,17	10,12	5,15	12, 3	17,16
White	13,13	8, 8	0, 8	6,10	3,11	7,10
Red	16,16	7, 7	15,15	22,22	18,18	17,17
Green	33,22	38,25	27,27	40,30	25,25	35,27
Total	16,16	12,13	7,10	17,19	10,14	12,14

[a] The percents for "Easy" and "Liked" can be found by subtracting each number from 100 respectively.

Table 11

5. For all the problems attempted, nearly 90 percent were rated by the students as "easy" and "liked."

6. The yellow type C, S, and M problems appear to be rather difficult.

7. Within the green problems, which were considered to be the most difficult, the S- and B-type problems were rated the hardest. (These types are characterized by the use of questions.)

8. For all problems, the C-, S-, and B-type problems were noted as the hardest. Although the S- and B-type problems are characterized by the use of questions, many of the C-type problems also contain questions.

9. The C-type problems were consistently rated the hardest for all difficulty levels save level green.

The data discussed in this section suggests the following recommendations related to the organization and content of the module:

Instructional Booklet

1. The "introductory" nature of this module should be discussed in the teacher's edition and perhaps mentioned in the title of the module.

2. The role of "tables" in problem solving should be explained to the teachers in the teacher's edition.

3. If teachers are to use this module without the aid of in-service education, the teacher's notes should provide a detailed presentation of the mathematics in the module.

4. The instructional booklet should provide additional emphasis related to the variety of ways to generate entries in tables. Implementing recommendation 3 could alleviate the weakness that motivated this recommendation and/or additional material could be provided in the student booklet.

Problem Deck

5. The quantity of reading (R)-type problems should be reduced and/or the difficulty of these problems should be increased for fifth and sixth grade students (see p. 140 for a further discussion of this recommendation).

6. The C-type problems at the blue difficulty level should be more evenly distributed among the set of blue problems.

7. The yellow type C, S, and B problems should be examined for their location in the deck. Some of these problems should be moved to a higher difficulty level.

8. The distinctions between all the problem types should be discussed in the teacher's booklet. Particular attention should be given to the distinction/similarity between the C- and B-type problems.

9. Relatively high percentages on "hard" and/or "dislike" suggest that the following problems be examined: blue - 8, 19, 20; yellow - 1, 16; red - 2, 3; green - 1.

10. The alphameric code on the problem cards should be explained in the teacher's booklet.

c. Effectiveness: The two previous sections concerned implementation and organization and content of the module. This section will be primarily concerned with the data from the module quiz related to student performance.

i. Teacher judgment. Data from the in-service session and the teacher interviews provide some evidence related to the effectiveness of the module. Some of the teachers' comments are:

- This is the best module we've used. (four teachers)
- The students had good attitudes. (six teachers)
- Some carry-over was noticed in other areas. (two teachers)

At some point during the evaluation activities every teacher commented that his/her students had attained the objectives of this module. Also, nearly every teacher stated that students of all ability levels were able to find some success with this module.

ii. Quiz results. In order to provide additional evidence of whether the students did attain the objectives of the module, the quiz results will first be analyzed and discussed related to each objective.

The objectives of the quiz were developed by the evaluation staff through examining the activities in the instructional booklet and the types of problems in the problem deck. As a result, the quiz results can be analyzed with respect to the content of the booklet and the problem deck.

Table 12 shows the results of the module quiz for each form and at each grade level. A specific criterion level for successful performance was not established. Rather, the quiz results were examined for any trends that suggested changes in the module. The five objectives to be measured by the quiz are given on pages 121-122. The quiz results suggest the following related to these objectives.

Objective 1: Nearly every student (93%) was able to correctly read a table. This data, together with the fact that very few students selected the R-type problems in the deck, suggests that the "reading" problems may be rather easy for most fifth- and sixth-grade students. Several teachers commented that reading tables was not a new skill for fifth- and sixth-grade students. However, they did feel that the lesson on reading tables was useful for motivation. Also, it is possible that the high performance on problems concerned with reading a table is the result of their prior experiences with the lessons related to completing tables. That is, the skill of reading a table may be developed as the student has experiences with completing tables.

Objective 2: The problems related to this objective require the student to complete a table with two categories. The problems related to objective 4 also require the student to complete a table with two categories. On all of the problems related to these two objectives, when the criterion is "correctly completing some of the entries," 80 percent of the students met the criterion. This level of success may perhaps be attributed to the large number of problems in the deck that were attempted where the student was (at least) asked to complete a two-category table. Except for the "reading problems" and 10 problems that have three

Table 12

Quiz Results: Form A

Problem No.	Criteria[a]	Maximum[b]	5th Grade Mean (N=41)	6th Grade Mean (N=54)
1(1)	-[c]	1	.89	.94
1(2)	-	1	.89	.94
1(3)	-	1	.91	.96
1(4)	-	1	.93	.98
2	correct entries	2	1.53	1.61
3	1st entry correct	1	.73	.77
	2nd entry correct	1	.66	.69
	3rd entry correct	1	.60	.63
	all entries correct	2	1.31	1.38
4	correct headings	1	.86	.91
	correct entries	2	1.56	1.64
	correct answer	1	.60	.63
5	used a table	1	.47	.50
	evidence of a table	1	.64	.67
	correct headings	1	.42	.44
	no structural error	1	.91	.91
	no executive error	1	.94	.94
	correct answer	1	.58	.61

[a] See p. 123 for details of the quiz criteria.

[b] Maximum refers to the total number of points possible on that item.

[c] For these problems, only the final answer was examined.

(continued)

Table 12 (Continued)

Quiz Results: Form B

Problem No.	Criteria[a]	Maximum[b]	5th Grade Mean (N=40)	6th Grade Mean (N=53)
1(1)	-	1	.91	.98
1(2)	-	1	.91	.98
1(3)	-	1	.90	.97
1(4)	selected 12	1	.88	.95
	selected 2	1	.88	.95
	selected 4	1	.86	.92
	selected 6	1	.87	.94
2	correct entries	2	1.58	1.70
3	1st entry correct	1	.71	.76
	2nd entry correct	1	.68	.73
	3rd entry correct	1	.67	.72
	4th entry correct	1	.69	.74
	all entries correct	2	1.30	1.40
4	correct headings	1	.87	.94
	correct entries	2	1.52	1.63
	correct answer	1	.63	.68
5	used a table	1	.27	.29
	evidence of a table	1	.32	.34
	correct headings	1	.23	.25
	no structural error	1	.92	.91
	no executive error	1	.78	.76
	correct answer	1	.35	.38

[a] See p. 123 for details of the quiz criteria.

[b] Maximum refers to the total number of points possible on that item.

[c] For these problems, only the final answer was examined.

categories, all of the problems in the deck involve completing two-category tables.

Objective 3: The problems related to this objective also ask the student to complete a table but now the table has three categories. Sixty-seven percent of the students correctly completed some of the entries. It is interesting that only 67 percent were able to complete the tables in the problems related to objective three while 80 percent were successful in the problems related to objectives two and four. Only ten problems in the problem deck ask the student to complete a table that has three categories. Also, only six percent of the problems attempted were this type. It appears that the ability to complete two-category tables does not necessarily make one effective at completing three-category tables. The teachers that have fifth- and sixth-grade students remarked that the fifth-graders had more difficulty completing the three-category tables than the sixth-graders. This remark is not supported by the quiz results since approximately 67 percent at each grade level correctly completed the tables. It is important to note that the objective of completing three-category tables was not an objective of the module but was included by the evaluation staff as an objective to be measured by the quiz since several problems in the problem deck involve three-category tables.

Objective 4: One of the criteria established for the problems related to this objective was the same as that discussed for objective two; that is, "the student will correctly complete some of the entries." The results related to this criterion are discussed above. The additional criteria for these problems on the quiz were that the students would (a) enter acceptable titles for the categories and (b) obtain the correct answer to the question(s). Nearly 100 percent were able to identify appropriate headings for the tables. The problems related to objective five also required the student to enter titles for the categories in the tables. In the problems related to objective five, nearly 90 percent entered acceptable titles. Only three problems in the booklet and 15 (10%) problems in the deck require the student to select titles for the categories. It appears that even though the module does not provide a great deal of practice at identifying titles, the students were successful at this task with the problems related to objectives four and five.

When the correct answer is used as the criterion, 66 percent of the sixth-graders and 62 percent of the fifth-graders correctly solved the problem. Recall that the data on problem card selections shows that the problems where the student is asked to answer a question using a table (types B and S primarily) were rated more difficult than the problems where they are not asked a question.

Objective 5: For the problems related to this objective the students were not given the framework for a table nor were they told to use a table to solve the problem. Table 13 shows that 39 percent of the students used a table to obtain an answer while 27 percent used a table to get a correct answer. Sixty-nine percent of those that did use a table did get the correct answer while only 36 percent of those who did not use a table found the correct solution. Most of the classes scored below 50 percent when the criterion is the correct answer.*

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* This, of course, may be due to the difficulty of the problems on the quiz.

Teacher 24's students performed considerably higher than the other classes. This teacher did not record the problem card selections but did report that the students used the cards twice a week for three weeks. Teacher 24's implementation procedures for the booklet and the students' characteristics (e.g., ability levels, socioeconomic background) were similar to the other teachers and as a result do not appear to be the reason for such a high performance.

Although only 49 percent of the students obtained the correct solution to the two problems related to objective five, the performance on problem five on form A was considerably higher than the performance on problem five on form B, 60 percent versus 37 percent (see Table 12). Also, 49 percent of the students used a table to solve problem five, form A, while only 28 percent used a table on form B.

Table 13

Percent of Students That Used Tables for the Problems Related to Objective Five

Teacher	Grade	Number of Students	Used Table[a]	Used a Table and got the Right Answer	Relative Percent[a]	Correct Answer
28	5	28	60(44,16)[b]	36(32,4)	60(73,25)	40(32,8)
08	5	28	8(8,0)	4(4,0)	50(50,0)	36(20,16)
05	5/6	25	44(28,16)	36(24,12)	82(86,75)	52(28,24)
29	5/6	30	29(23,6)	12(6,6)	41(26,100)	45(32,13)
01	6	27	44(37,7)	26(22,4)	59(59,57)	41(26,15)
09	6	26	29(13,16)	17(13,4)	59(100,25)	46(38,8)
24	6	32	60(32,28)	55(32,23)	92(100,82)	81(39,42)
Mean			39(26,13)	27(19,8)	69(23,62)	49(31,18)

[a] Percent who used a table and got the right answer divided by the percent who used a table.

[b] The first number indicates the percent for form A and the second number the percent for form B.

iii. Summary - objectives one through five. For the fifth- and sixth-grade students in this field test, nearly every student was able to read a table. Most students (80%) were able to generate some entries in two-category tables. Fewer students (67%) were able to generate some entries in three-category tables. The students in most cases were able to identify appropriate headings for a table. Approximately 50 percent of the students obtained a correct solution to the problems related to objectives four and five; however, the performance was considerably higher on form A (60%) than on form B (37%).

iv. Further analyses. Two additional analyses are possible with the quiz results. First, the data provided by three teachers with respect to problem card selections will be examined for a relationship between the number of cards that were attempted and the performance on the quiz. Next, one teacher's class was administered the module quiz without having any experiences with the problem deck. This class's quiz results will be compared to the mean scores for all the students.

Table 8 on page 131 shows the number of problems attempted for three teachers. The students in class 29 attempted 580 problems while 415 and 379 were attempted in the others. Table 14 shows that the performance of class 29 was greater than or equal to both of the other classes for five of the eight categories. Since most of the problems in the deck ask the student to complete two-category tables and class 29 attempted the most problems in the deck, it follows that class 29 attempted more problems of this type. Problem number two asks the student to complete a two-category table and Table 14 shows that class 29 performed considerably higher than the others. This

Table 14

Quiz Results on the First Four Problems for Three Teachers

	Problem Number							
Teacher	1(1-3)[a]	1(A4)[b]	1(B4)	2	3	4A[c]	4B	4C
29	99	100	87	82	58	84	67	52
28	92	92	90	64	52	80	68	52
08	89	92	83	64	58	96	74	52

[a] Entries in this column represent the mean percent of correct answers for problem 1, part 1-3, on both forms.

[b] 1(A4) and 1(B4) indicate the 4th part of number 1, forms A and B respectively.

[c] 4A - Acceptable titles were entered.
4B - Some entries were correctly completed.
4C - correct solution

trend was not present in problem four (4B); however, the performance scores for all three groups are nearly the same. When the correct solution is the criterion, class 29 performed equally well for problem number four. Also, Table 13 shows that class 29 had a higher percentage of correct solutions than classes 28 and 08 on problems five. The evidence in Tables 13 and 14 shows that for these three teachers the class that attempted more problems in the deck generally performed higher than the other two. For the eight categories in Table 14 it is interesting that the scores for class 29 are higher than the mean scores for all students on only three categories. Class 29 is primarily a fifth-grade class and classes 28 and 08 are completely fifth grade. The grand means were calculated with fifth- and sixth-grade classes and the sixth-graders generally scored higher than the fifth-graders, especially the sixth-graders in class 24. Therefore, it appears that among the fifth-graders, the students that attempted the most problems in the deck generally performed higher than the students that attempted fewer problems. Class 05 contains fifth-graders and generally performed higher than class 29. However, only approximately 30 percent of the students in class 05 are fifth-graders while over 50 percent are fifth-graders in class 29.

Teacher 09 was ill for an extended period of time. As a result, the students in his class did not work at all with the problem deck before the module quiz was administered. Table 15 shows that the mean performance of the students in class 09 was higher than the mean for all students on seven of the eight categories. However, when the students in class 09 are compared to other sixth-graders (Table 16), the mean performance is higher on only three of the categories and by only one percentage point in each. For the categories in which the mean for the students in class 09 is less than the mean for all sixth-graders, the mean difference is six percentage points. Therefore it appears that among the sixth-graders, those students that attempted the problems in the deck generally performed higher than those students who did not attempt any of the problems.

Table 15

Quiz Results for One Teacher Who Did Not Work with the Problem Deck

	Problem Number							
Teacher	1(1-3)[a]	1(A4)[b]	1(B4)	2	3	4A[c]	4B	4C
09	99	100	98	94	81	92	81	63
Grand Mean for Teachers	93	96	91	81	67	90	79	64

[a] Entries in this column represent the mean percent of correct answers for problem 1, part 1-3, on both forms.

[b] 1(A4) and 1(B4) indicate the 4th part of number 1, forms A and B respectively.

[c] 4A - Acceptable titles were entered.
4B - Some entries were correctly completed.
4C - correct solution

Table 16

Quiz Results for Classes with
Sixth-Grade Students

Teacher	Problem Number 1(1-3)	1(A4)	1(B4)	2	3	4A	4B	4C
05	96	100	100	95	76	93	91	81
01	99	100	100	98	78	100	98	74
24	97	100	100	83	84	100	94	84
09	99	100	98	94	81	92	81	63
Mean	98	100	100	93	80	97	91	76

v. Summary of effectiveness. This section of the evaluation was primarily concerned with the students' performance on the module quiz. It is important to mention again that this module is part one of a two-module sequence. Some of the comments below might no longer apply if the second half of the sequence were developed.

1. There is some evidence to suggest that the module may have had a positive effect on many areas (e.g., attitudes, ability to solve problems using tables, etc.) (see p. 139).
2. "Reading tables" may not be a new skill for the fifth- and sixth-graders (see p. 140).
3. Most students were able to complete some entries in the two-category tables. The three-category tables were more difficult.
4. Most students were able to identify appropriate titles for the categories of a table.
5. Most students did not use a table to solve problems when the use of a table was not suggested.* However, the percentage of students

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* The "use of a table" was determined by examining students' work on the quiz. It is possible that students used tables but did not draw the table on the quiz form.

that obtained the correct solution was higher among the students that did use tables than among the students that did not. This suggests that the use of a table did help the students to find the correct solutions to the problems on the quiz.

6. There is evidence that at grade five the students that attempted the most problems in the deck performed best on the quiz. Also, there is evidence that at grade six the students that attempted some problems in the deck performed better than the students that did not attempt any problems in the deck. This suggests that attempting the problems in the deck did have a positive effect on the performance on the quiz.

4. *Summary and Recommendations*

The formative evaluation of Using Tables to Solve Problems was conducted under the general design of the formative evaluation given in Chapter A of this report. Data was collected concerning the three major questions of the formative evaluations related to the implementation, organization and content, and effectiveness of the module. This section will summarize the results of the evaluation related to each of the major questions.

a. Implementation:

1. The instructional booklet and the problem deck were implemented in a variety of ways. Every teacher felt that his/her methods were appropriate for his/her students. The recommended teaching procedures given in the teachers' booklet (see p. 119-120) appear to be one method for using the module. The teacher's booklet should list several of the methods that have been used to implement the module.

2. It appears that the booklet can be used in six days (one day per lesson) with most fifth- and sixth-grade students. Lessons 2 and 3 should be shortened. The problem deck was used for approximately three weeks prior to administering the module quiz. All classes, however, did not spend the same amount of time with the problem deck during the three weeks. Although the teachers stated they could have used more time with the deck, they felt that their procedures for implementing the problem deck for three weeks were adequate preparation for the quiz. The teacher's booklet does not identify a recommended amount of time for the students to work in the deck. Even if there is not a recommended amount of time, some discussion of this point should be included in the teacher's booklet.*

3. Most of the students were allowed to select their own cards from the deck. Three teachers reported the card selections with 580, 415, and 379 problems attempted in these classes. The results on the module quiz show that the class that attempted the most problems generally performed better on the quiz. The module developers have not identified a number of problems that should be attempted at each difficulty level by students of different ability levels. Even if such a number is not to be identified, some discussion should be provided related to the findings of this evaluation concerning the relationship between performance and problem card selections.*

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* This issue is discussed in the revised teacher's module developed as a result of this report.

b. Organization and content:

4. The "introductory" nature of this module and the role of "tables" in mathematical problem solving should be discussed in the teacher's booklet.
5. The teachers had difficulty identifying the variety of ways one can generate the entries in the tables. If teachers are to use this module without the aid of in-service education, the teacher's notes should provide a detailed presentation of the mathematics in the module.
6. The distinctions between all the problem types should be discussed in the teacher's booklet.
7. Specific organization and content recommendations are included in the section titled "Organization and Content" and in Appendix D.

c. Effectiveness: The section related to the "effectiveness" of this module was primarily concerned with the students' performance on the module quiz. The following comments are related to the effectiveness of the module.

8. Most students were able to complete some entries in the two-category tables. The three-category tables were more difficult.
9. Most students did not use a table (i.e., draw a table) to solve a problem when the use of a table was not suggested. The quiz results indicate that the percent of students that obtained the correct solution was higher among the students that did use tables than among the students that did not.

The teacher feedback and the results of the module quiz provide evidence of the "introductory" nature of the objectives of this module. The development of the second part of this module would be a real contribution to its potential effectiveness.

APPENDICES TO

TECHNICAL REPORT III: MODULE DEVELOPMENT AND FORMATIVE EVALUATION

APPENDIX A: Evaluation Instruments and Forms

APPENDIX B: Organizing Lists Quizzes and Data

APPENDIX C: Using Guesses to Solve Problems Quizzes and Data

APPENDIX D: Using Tables to Solve Problems Quizzes and Data

(Appendices Under Separate Cover)